THE ELECTRONICS & COMPUTER MAGAZINE

JANUARY 1999

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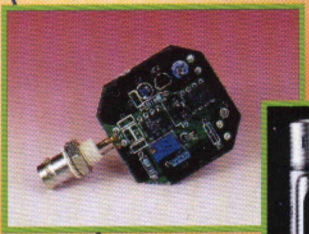
winning projects from our PC software design contest : **measurement** • **development** • **communication**



RF signal level meter

Iridium: telephone by satellite

PC EXTRA FOLLOWS P.38

general-coverage receiver 0.15 – 32 MHz AM/FM/SSB

conductance meter

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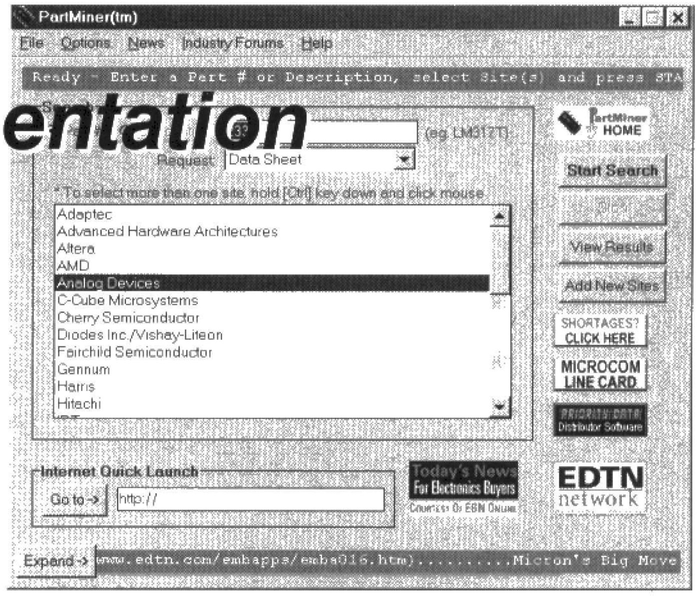

Designing electronic circuits almost invariably calls for extensive descriptions of the operation and typical application of the more complex components in your design. Although a fair amount of documentation may be found in databooks and CD-ROMs (like Elektor's Datasheet Collection Vol. 1 and 2), the Internet is also a vast resource when it comes to finding datasheets.

These days, many manufacturers of electronic components use Internet sites to offer vast amounts of data on their products. This service is usually free of charge and available to anyone. Most datasheets are available in the so-called PDF format which can be read and printed by the popular Acrobat Reader from Adobe. This reader program is free of charge, and may be downloaded from *www.adobe.com/supportservice/custsupport/download.html*

Often, the main problem is to locate the datasheet of a particular component. The good news is that special search engines are available to help you find what you want. **Partminer** is a good example, it may be found at *www.partminer.com/partminer/index.html.* Using a helper program (which may be downloaded free of charge), you can start looking for type numbers and descriptions. Partminer then makes the connections with the relevant manufacturer sites, and starts looking there. You can report new manufacturers to Partminer for inclusion in the search overview.

Another datasheet search engine is called **WebStir**. You may find it at *webstir.infoquick.com/iq-home.html.*

Like Partminer, this engine offers extensive information and search options with many manufacturers. It is, however, not a free service. None the less, it is still of interest to the hobbyist because the program may be used on a 30-day trial basis, and up to 10 datasheets may be downloaded free of charge.

There are also sites providing their own component databases or links for that purpose. An example is the Component Database Server of the Center for Electronic Design, Communications and Computing (CEDCC) at Penn State University, USA. Currently, this server holds mainly Motorola and Harris component datasheets.

Component suppliers, too, are starting to offer datasheets by means of online services. Although the English-language web site of Conrad has been 'on the air' for some time at

www.conrad-electronic.com

it does not (or not yet) offer the datasheet service available on the web site run by the mother company in Germany, at

www.conrad.de/index/html

Searching for a particular part is not easy, and the Conrad catalogue should be used alongside the information on web pages.

Finally, there is Leeds-based Farnell at

www.farnell.com/uk/index.html

Their web site contains datasheets on no fewer than 1500 components, and is certainly worth a visit.

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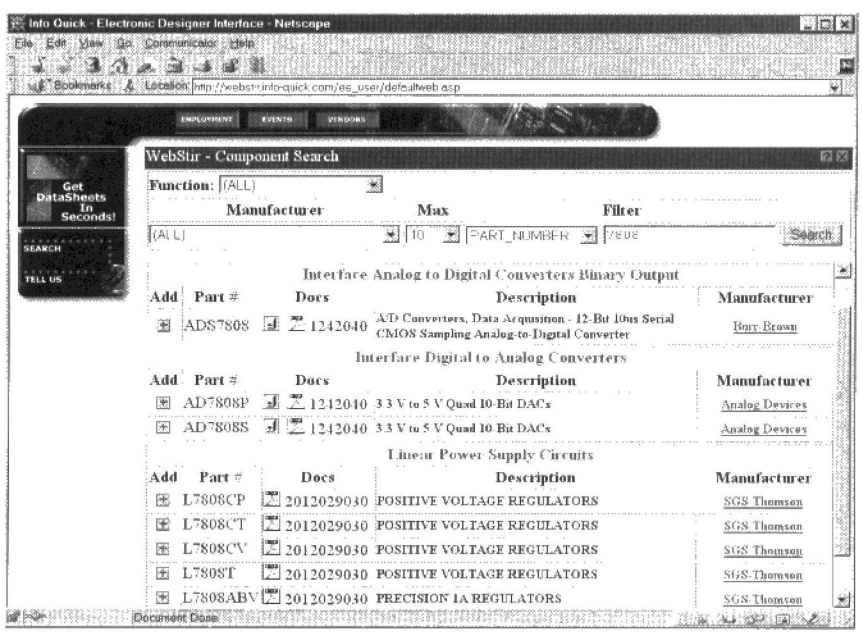
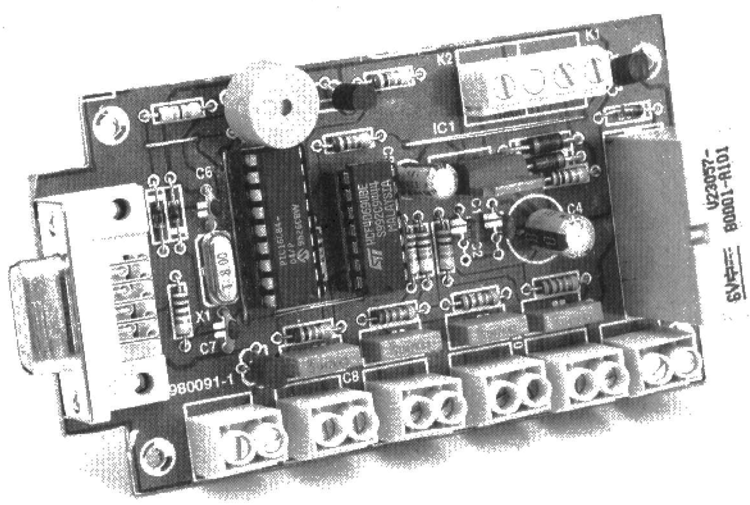


home alarm system

programmable burglar deterrent with a PC interface

Crime in general is still on the rise, and having an alarm system installed is no longer a privilege of the wealthy. This article shows that an advanced alarm system to protect your home and valuables can be very compact indeed. Using the PC, the authorized user is able to program the main parameters of the alarm system.



Main features

Processor:	*PIC17-6F84*
Serial port:	*19,200 bits/s*
Inputs:	*direct and delayed*
Outputs:	*relay for siren*
User indication:	*buzzer*
Alarm contacts:	*normally closed*
Interface for optional phone dialler	
Key switch to arm system	
Actuation delay (default):	*20 seconds*
Siren on time:	*1 to 255 seconds*
Adjustable actuation delay:	*1 to 99 seconds*
'Armed' indicator	
Battery back-up	

Design by H. Sommen

By popular demand, PIC processors and alarm systems are two subjects which are often covered in this magazine. In this article, you find the two combined in a programmable alarm system for home construction. Here, a PIC processor is employed as the logic 'glue' between the various sensors (detection devices) and alarm actuators. Besides this function, the PIC also handles all communication between the alarm system and an (optional) PC of the IBM/compatible type.

Using a simple RS232 link and a standard terminal program, the main parameters of the alarm, including alarm time, may be programmed.

Optionally, the alarm may be extended with a separate telephone dialler, which allows 'silent signalling' to be implemented. The relevant hardware is not discussed in this article, but we intend to cover it in a future issue of *Elektor Electronics*. A commercially available dialler unit may be connected to a dedicated output on the alarm system. If the alarm goes off, transistor T1 will conduct for about one second — long enough to actuate an external dialler.

THE APPROACH

The circuit diagram of the home alarm system is given in **Figure 1**. The connections to the various alarm detection devices have been kept as simple and universal as possible. Assuming that devices with normally-closed (nc) contacts are used, buffer inputs (IC3a-IC3d) are pulled low via a group of connection terminals (K3, K6, K7, K8). A pull-up resistor and a 470-nF afford ample noise suppression.

The connection point of the main switch (K3) has an extra indicator. If LED D6 is on, the alarm system is armed. This input is therefore best connected to a key switch.

The detection device connected to terminal block K8 is 'interpreted' with an adjustable delay (for example, 20 seconds). When the alarm is armed, an integrated buzzer starts to sound to indicate that a contact in this group is opened within the delay period. This delay is needed to leave the building without setting off the alarm. The door you normally use to leave the building is therefore connected to the 'delayed' input.

When you enter the building, the same delay is available to de-activate the alarm. However, the buzzer will not sound during this period to prevent it giving away the location of the alarm control unit.

The alarm contacts connected-up to terminal block K7 produce an instant alarm when opened. The upshot is that all 'nc' detection devices are connected in series and to this input. If any one of the switches is opened, the detection loop is interrupted, and the alarm is set off.

The last input is the 'tamper' input. The switch protecting the alarm enclosure is connected to this input. If someone attempts to open the enclosure while the alarm is in the 'armed' state, this will not go unnoticed because the alarm will go off.

The alarm actuator (for example, a siren) is switched by relay Re1. This relay will be energized for a programmable period when an alarm condition is detected. The default 'on' time is 180 seconds. Using the PC, however, you may set any period between 1 and 255 seconds.

If an alarm condition has occurred, and the siren has been switched off, LED D8 will remain on. In this way, when you come home, you are informed that the alarm went off at least once during your absence. The LED activity can be cleared by pressing reset button S1.

What remains to be discussed at this point are the connections of the power supply and the lead-acid battery. The power supply (approx. 13 V) has to be connected to terminal block K1, while the 12-V lead-acid battery goes to K2. The battery is kept topped up via resistor R3. The three-pin regulator in the power supply section provides the correct supply voltage for the microcontroller in the alarm control unit.

The battery used in the alarm system should have sufficient capacity to power the alarm control unit, the siren (or flashlight) and the telephone dialler. The battery is incorporated in the design to ensure that the alarm system keeps working when the mains electricity system is tampered with by burglars.

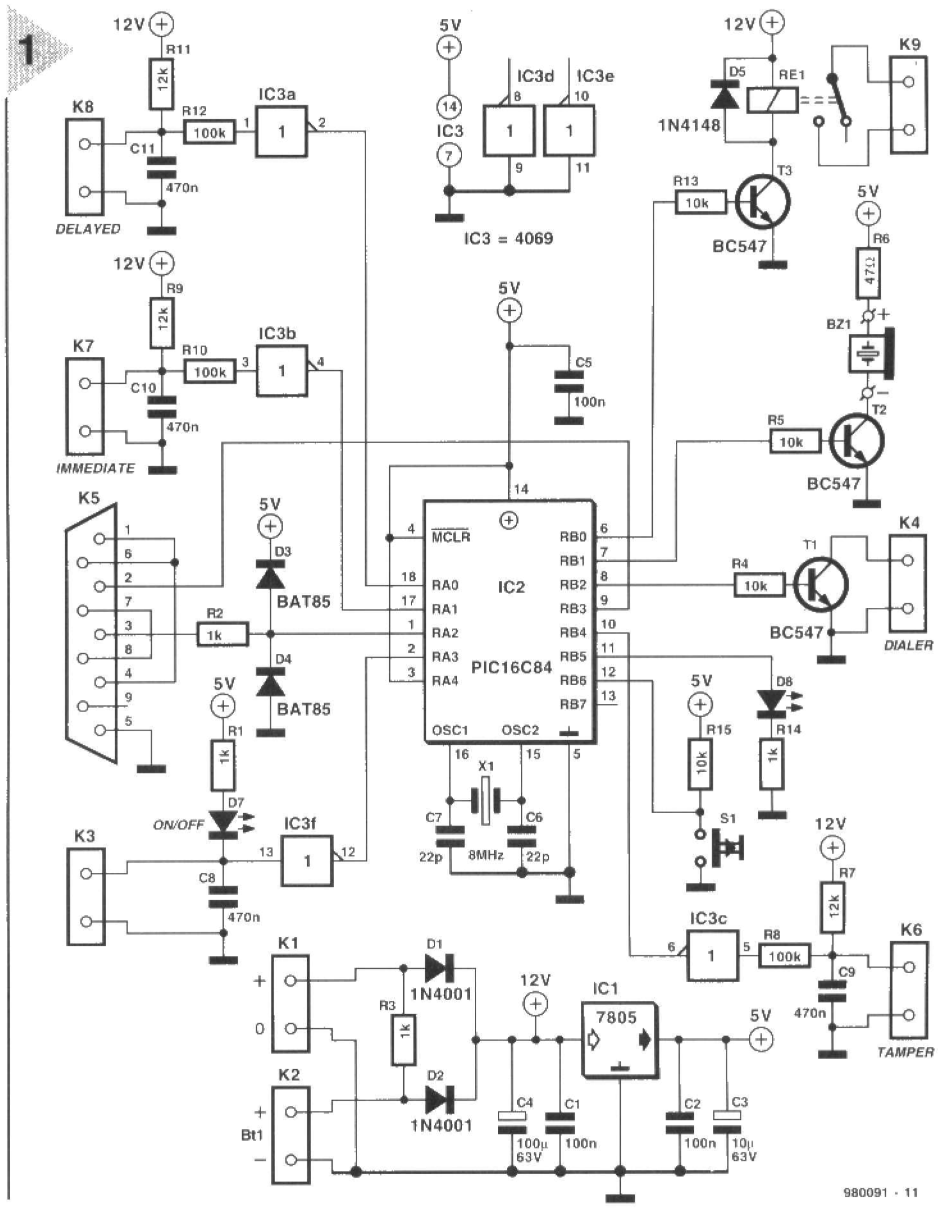


Figure 1. The program stashed away in the PIC processor allows the hardware to be kept very simple indeed.

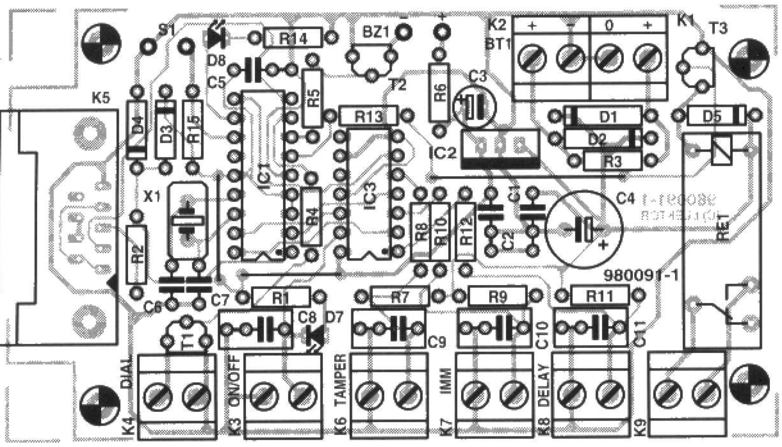


Figure 2. Copper track layout and component mounting plan of the printed circuit board designed fore the alarm system.

COMPONENTS LIST

Resistors:
R1,R2,R3,R14 = 1kΩ
R4,R5,R13,R15 = 10kΩ
R6 = 47Ω
R7,R9,R11 = 12kΩ
R8,R10,R12 = 100kΩ

Capacitors:
C1,C2,C5 = 100nF
C3 = 10μF 63V radial
C4 = 100μF 63V radial
C6,C7 = 22pF
C8,C9,C10,C11 = 470nF

Semiconductors:
D1,D2 = 1N4001
D3,D4 = BAT85
D5 = 1N4148
D6,D7 = LED, red, high efficiency
T1,T2,T3 = BC547

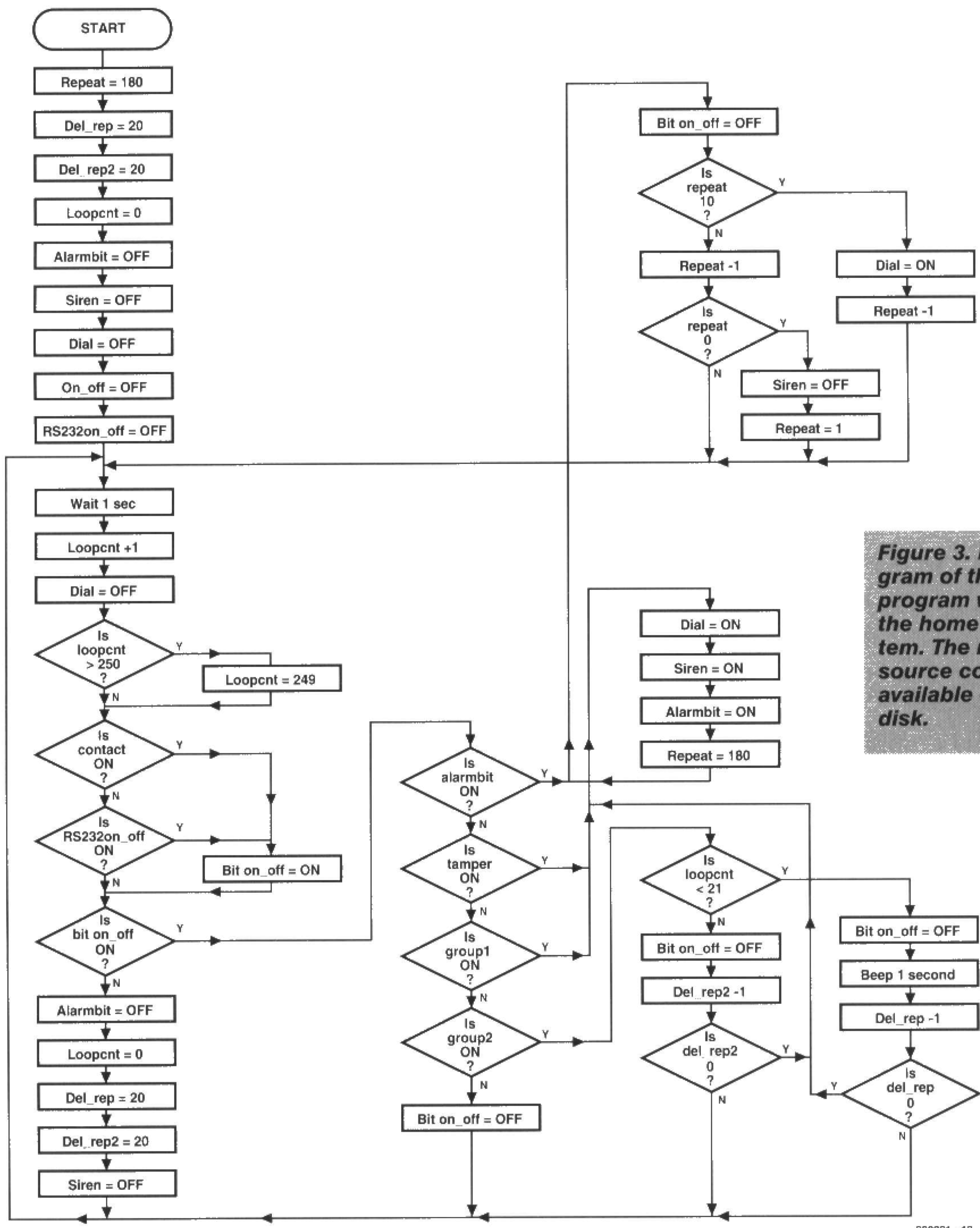
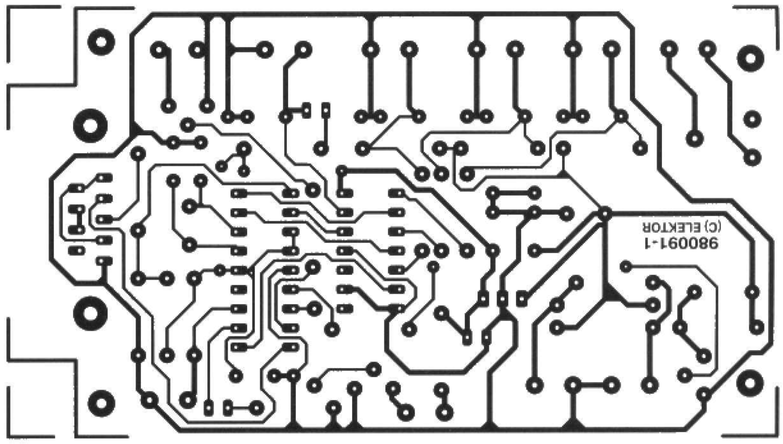


Figure 3. Flow diagram of the main program written for the home alarm system. The relevant source code file is available on floppy disk.

IC1 = PIC16F84
(order code 986519-1)
IC2 = 7805
IC3 = 4069

Miscellaneous:
K1-K4,K6-K9 = 2-way PCB terminal block, raster 5mm
K5 = 9-way sub-D socket (female), PCB mount, angled pins
Bz1 = piezo buzzer, 5V DC
X1 = 8 MHz quartz crystal
S1 = push-button, 1 make contact
Re1 = 12-V relay, 1 change-over contact (e.g., Siemens V23057-B0001-A002)
PCB, PIC and floppy disk (set), order code 980091-C
PCB only, order code 980091-1
Source code disk only, order code 986028-1.



Optional PC control

Serial communication with your PC takes place via 9-way connector K5. On the printed circuit board, all relevant handshaking signals are available, allowing a standard (commercially available) RS232 cable to be used. Resistor R2 and diodes D3 and D4 convert the RS232 signal levels on the interface into TTL levels that can be processed by the alarm circuit.

Construction

Building this circuit should not present problems because a ready-made high-quality printed circuit board (PCB) is available from the Publishers (see the Components List, and the Readers Services page elsewhere in this issue). The copper track layout and component-mounting plan of this compact board are given in **Figure 2**.

Silicon heart

The PIC processor in the present project underlines the fact that microcontrollers allow loads of functionality to be combined in a single compact case. Here, the processor ticks at a rate of 8 MHz.

The control software programmed into controller ROM consists of a large loop which is repeated every second. As shown by the flow diagram in **Figure 3**, the basic structure of the program boils down to continuous testing of bits and/or input levels. Based on the results of these 'interrogation' activities, the processor determines whether or not an alarm condition has to be signalled. Because the program has a relatively simple structure, new features are easily added with the aid of the source code file, which is available separately on floppy disk (order code **986028-1**).

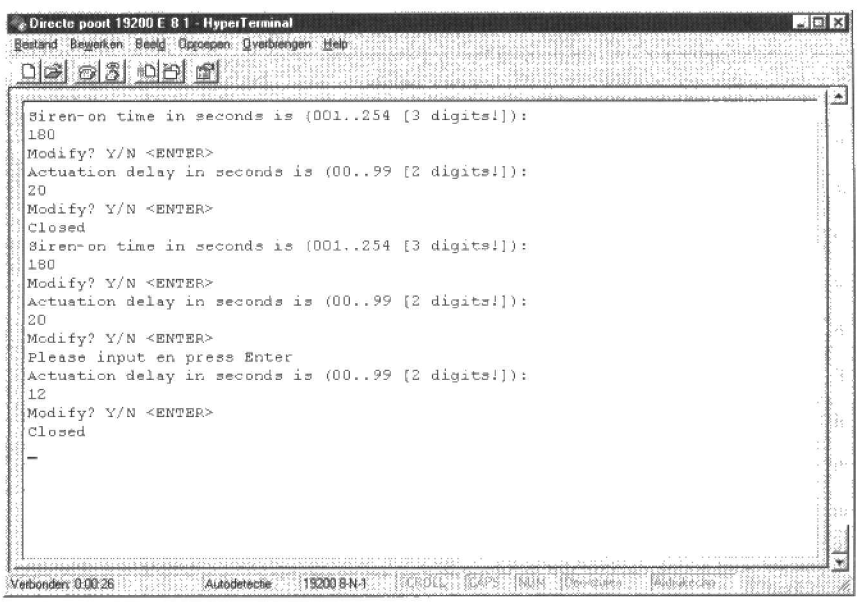
Serial communication between the PC and the alarm control unit is only possible in 'standby' mode, i.e., when the switch contact on K3 is open. Run a terminal program on your PC (or connect a real 'dumb' terminal), and select these communication parameters:

19,200 bits/s, even parity, 8 databits and 1 stopbit.

'Local echo' should be enabled on the terminal. Press the Return key and follow the instructions on the screen. The new parameters are effective after you switch the alarm control off and on again. The screendump in Figure 4 shows the information which should appear on the terminal display.

(980091-1)

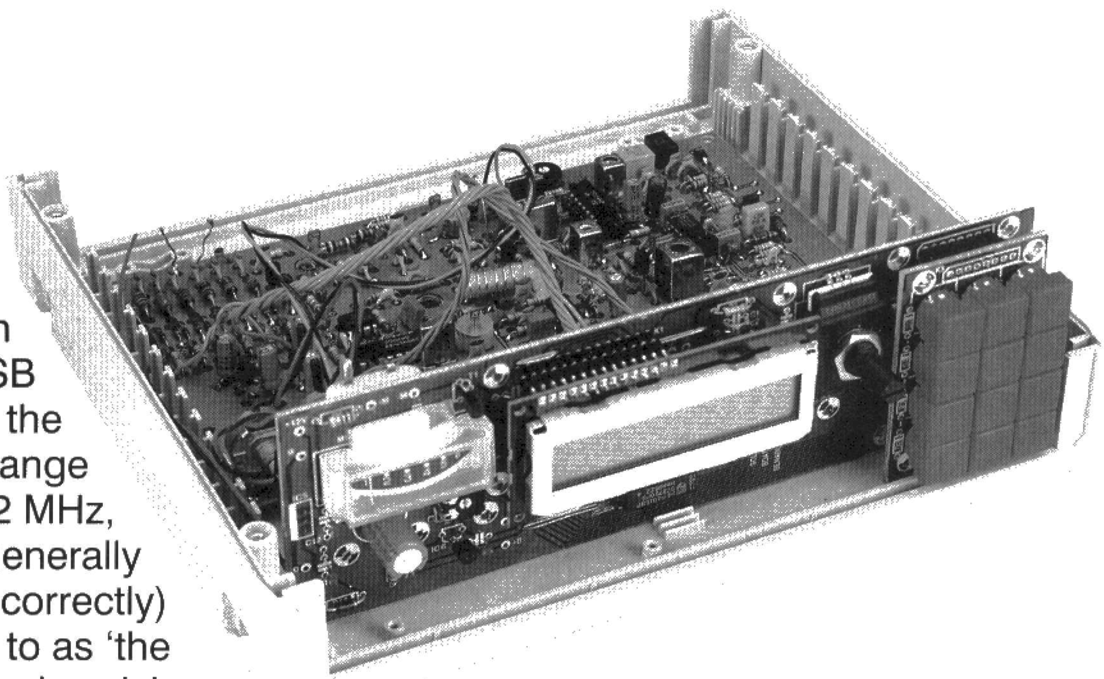
Figure 4. The home alarm system is easy to program if you have a terminal or a PC running a communication program like Telix, ProComm or HyperTerminal.



general-coverage receiver

part 1: circuit descriptions

This two-part article describes an AM/FM/SSB receiver for the frequency range 0.15 – 32 MHz, which is generally (but incorrectly) referred to as 'the shortwave bands'. The receiver is micro-processor controlled and avoids many of the pitfalls traditionally associated with RF construction.



Main Specifications

- *Double conversion superheterodyne receiver, 1st IF 45 MHz, 2nd IF 455 kHz*
- *Microprocessor control of synthesizer tuning and other receiver functions*
- *150 kHz to 32 MHz tuning range in 1-kHz steps.*
- *Selectable selectivity: 3 kHz (narrow) or 12 kHz (wide)*
- *Internal 6-band preselector with automatic band switchover*
- *12-key keyboard for frequency entry, mode and bandwidth selection*
- *16-character LCD shows receive mode, bandwidth, frequency and preselector band*
- *Memory for 21 frequencies, incl. bandwidth and mode*
- *Spurious product rejection >50 dB*
- *Audio output power approx. 1 W into 8 Ω.*
- *Power supply 15 V, max. 400 mA (approx. 90 mA without audio and LCD backlight)*

Design by G. Baars, PE1GIC

The receiver we're about to describe is the product of many hours of designing, testing and programming by the author, a licensed radio amateur from the Netherlands. Throughout the design process, the emphasis has been on repeatability, ease of construction and avoidance of many of the pitfalls commonly associated with building radio equipment. As many of you will avow, the two best known pitfalls are winding your own coils and non-availability of specialized test equipment to align the receiver, or, indeed, any other RF project you may want to build.

So how are these problems solved? Well, the present receiver has only one inductor you have to wind yourself, and the use of ready-made filters and transformers in the IF sections obviates the need for complex constructions and adjustments. If you are a careful builder with some experience in RF technology, then the receiver should work spot-on, and a minimum of adjustments is needed to tweak it for optimum performance. The good news is that these adjustments only require the built-in S meter, your hearing ability, and possibly a voltmeter.

THE CONCEPT

The block diagram of the general-coverage receiver is shown in **Figure 1**. The design is that of a double-conversion superheterodyne receiver with a 'high IF', which means that the first intermediate frequency (IF) is well above the highest receive frequency.

The antenna signal is first taken through a preselector stage whose main purpose is to reduce the risk of interference and cross-modulation products caused by very strong signals. The preselector is manually tuned for best performance. The second function of the preselector is to make the receiver input virtually independent of the antenna used: in fact, anything ranging from a simple telescope antenna to a full-blown 'beam' (with a cable impedance of 50 Ω) or a long-wire may be connected. Alternatively, for indoor use, consider a small magnetic-loop antenna such as the superb DJ8IL design described in the September 1998 issue of *Elektor Electronics*.

The preselector is followed by a preamplifier stage with manually adjustable gain. Here, again, one of the most important design considerations is to keep strong signals away from the input of the next stage, the mixer. If you are new to shortwave reception, then remember that your main concern is not dredging in the noise to get the weakest possible signal *into* the receiver, but to keep multi-megawatt signals *out*.

The local oscillator (LO) signal for the first mixer is supplied by a synthesiser circuit which can be tuned in steps of 1 kHz across the range 45.150 MHz to 77.000 MHz. The synthesizer consists of the usual ingredients: a VCO (voltage-controlled oscillator) a prescaler, and a loop filter for suppression of the reference frequency (here, 1 kHz). Like a number of other sub-circuits in the receiver, the synthesizer is digitally controlled by a central microprocessor.

The output signal of the first mixer is taken through a 45 MHz filter with a bandwidth of about 15 kHz. The main function of the filter is to suppress the image frequency of the second mixer, which occurs at 44.090 MHz (44.545–0.455).

The first IF signal (45 MHz) is heterodyned down to 455 kHz by means of the second mixer and the second LO signal, which is supplied by a crystal oscillator operating at 44.545 MHz. The mixer is followed by two bandpass filters, one with a width of 3 kHz for 'narrow-band' mode (SSB), and one with a width of 12 kHz for FM and AM reception. The gain of all IF amplifier stages (45 MHz and 455 kHz) is controlled by an AGC circuit (automatic gain control). Because the AGC voltage is a measure of the received signal strength, it can also be used to drive the S-meter.

The last 455-kHz amplifier drives two demodulators (for AM/FM reception), and a product detector (for SSB reception.) The oscillator in the product detector can be pulled a little to allow USB/LSB selection. The relevant control is labelled BFO (beat frequency oscillator). Analogue switches are used

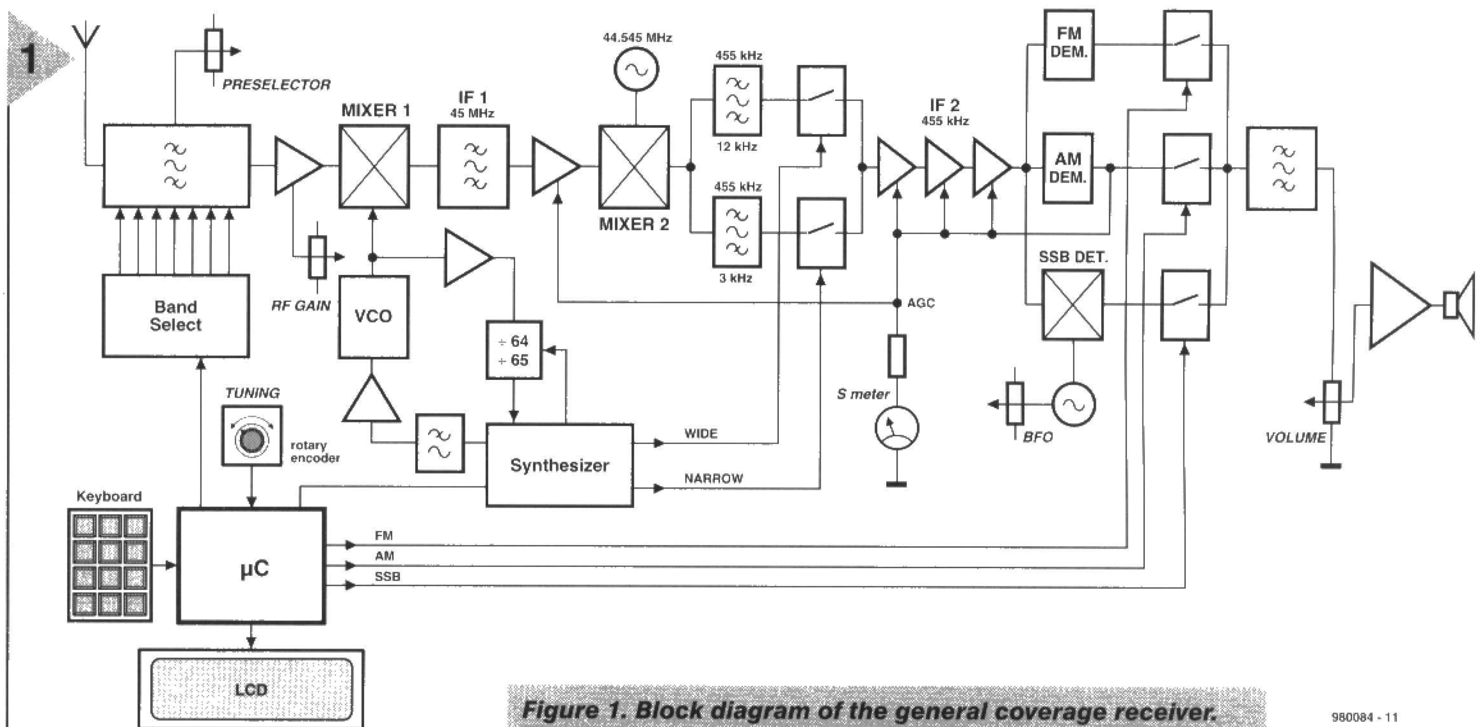


Figure 1. Block diagram of the general coverage receiver. The design is a double conversion superheterodyne with high-side injection for the first LO. The use of a 'high' first IF (45 MHz) guarantees a minimum of in-band generated spurious products while also reducing the risk of IF breakthrough. Note that many functions are controlled by a central microprocessor.

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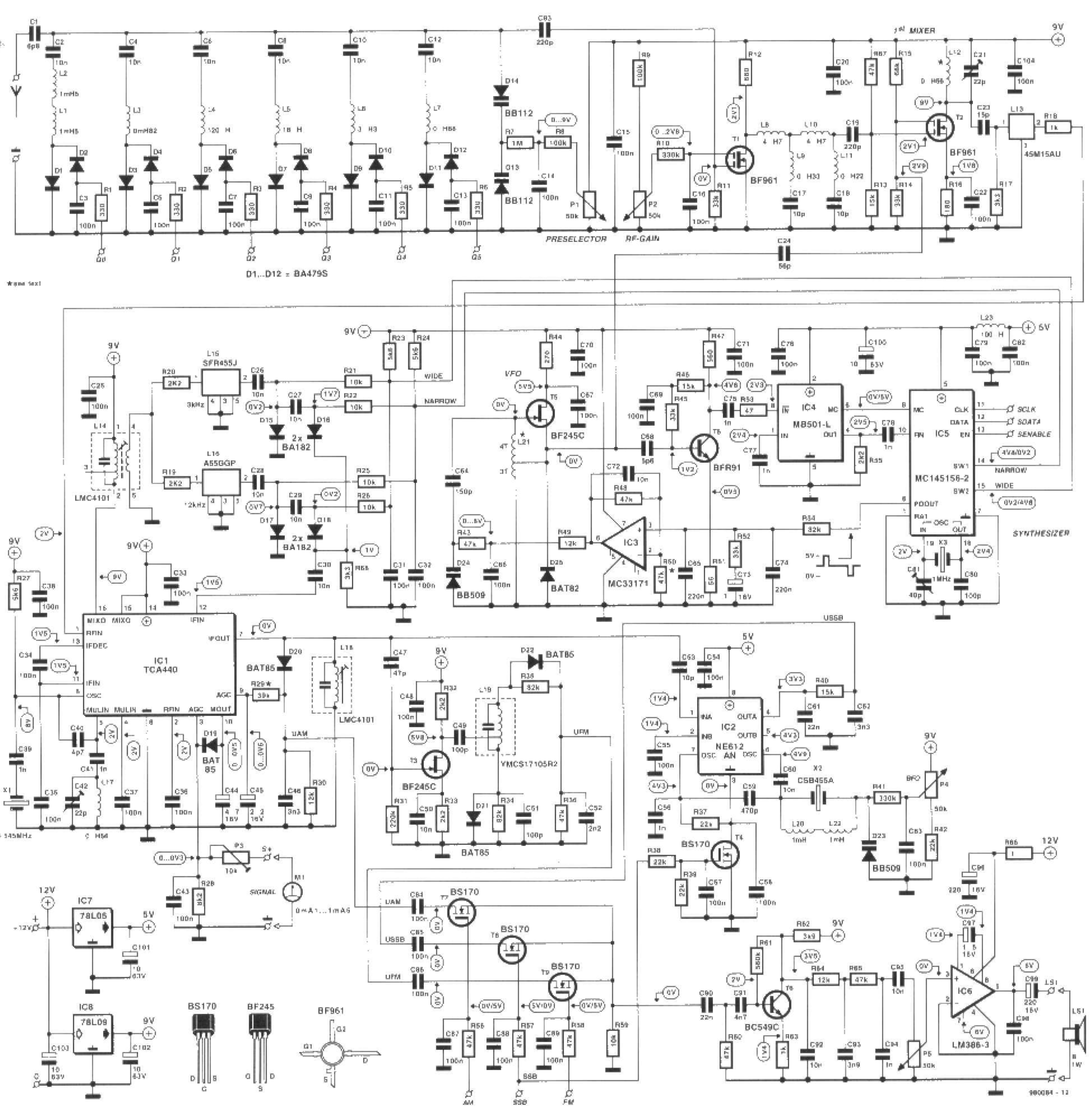

Figure 2. Practical circuit of the RF sections of the general coverage receiver. Most of the functions defined in the block diagram will be easy to find back in this schematic.

to feed one of the demodulator/detector outputs to the input of the audio amplifier, by way of a 'speech' filter with roll-off points at 450 Hz and 3.3 kHz.

The microprocessor circuit controls the preselector, the synthesizer, the IF bandwidth (wide/narrow), the mode selection (AM/FM/SSB), and the LCD (liquid crystal display). Its 'input devices' are a rotary encoder for the receiver tuning, and a small keyboard for direct frequency entry and several other functions like channel memory control, manual bandwidth selection (3 kHz/12 kHz), etc.

Practical circuit

Drawing a block diagram is one thing, actually implementing the functions with real components is quite another.

Although the circuit diagram in **Figure 2** may look large and complex at first, its operation is relatively easy to understand thanks to the previous description of the block diagram. Let's take the sub-circuits one by one.

Preselector

The active element is a type BF961 dual-gate MOSFET, T1, which guarantees minimum loading of the inductors in the preselector. PIN diodes are used to allow the outputs of a decimal counter to switch the requisite inductors on and off. The counter, in turn, is controlled by the microprocessor. For the sake of repeatability, ready-made miniature chokes from the E12 series are used in the preselector. Their Q factors remain as high as possible thanks to the small capacitive load presented by the DG MOSFET. The preselector has six ranges:

1: 150 – 370 kHz
2: 370 – 900 kHz
3: 900 – 2200 kHz
4: 2200 – 5400 kHz
5: 5400 – 13200 kHz
6: 13200 – 32000 kHz

The inductive part of the preselector is brought to resonance by the capacitance formed by a pair of varicap diodes, D14-D13. The varicap control voltage has a range from 0 to 9 V, and is supplied by the wiper of the preselector tuning control, P1.

The gain of the DG MOSFET is controlled in traditional fashion by means of a direct voltage on gate 2. Although the preselector already affords considerable suppression of unwanted frequencies, the MOSFET is followed by

an additional low-pass filter with two 'notch' sections, L9-C17 and L11-C18, for virtually complete suppression (–50 dB) of image frequencies and out-of band products.

1st mixer and synthesizer

In many up-market SW receivers, a double-balanced type (DBM) is employed as the first mixer to guarantee excellent large-signal behaviour. The main disadvantages of a passive DBM are the high level of the LO signal (typically 7 dBm), and the inherent conversion loss of about –7 dB. The present receiver employs a DG MOSFET in the first mixer. As opposed to a DBM, the MOSFET

Figure 3. The microprocessor control circuit is based on a PIC16F84. To keep receiver-internal interference to a minimum, the PIC is in 'sleep' mode most of the time.

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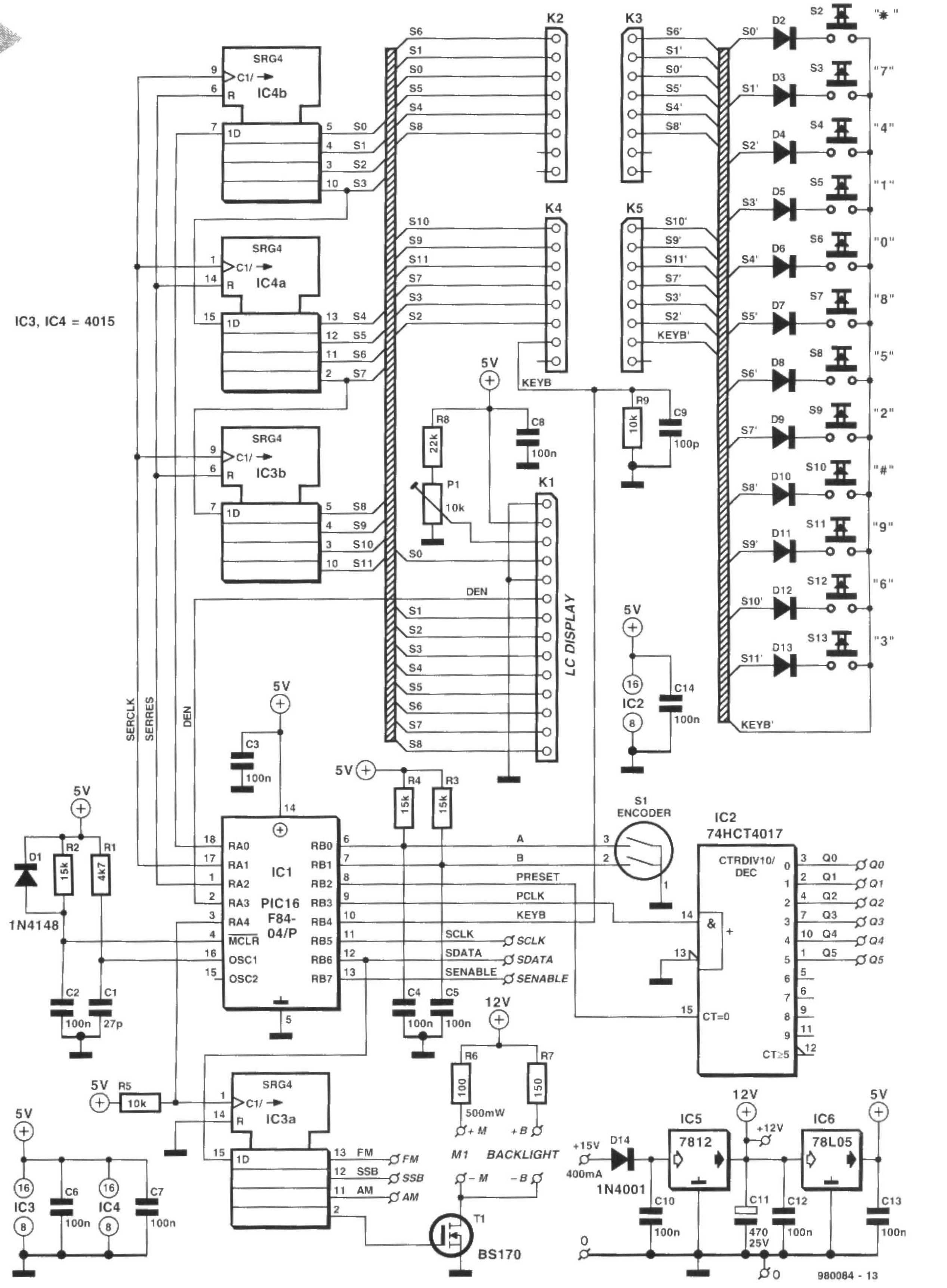


offers a conversion gain of about 10 dB, and it works fine at a relatively small LO signal.

The combination of a synthesizer IC type MC14156-2 (from Motorola) and a dual-modulus (÷128/÷129 or ÷64/÷65) divider type MB501L (from Fujitsu) forms a phase-locked loop (PLL) whose step size equals the reference frequency of 1 kHz, which is derived from quartz crystal X3 by an on-chip divider. The MC14156-2 is controlled by means of serial information supplied by the microprocessor. The error signal supplied by the synthesizer IC is filtered by a loop filter built around an opamp type MC33171 (IC3). Because the 1-kHz reference-frequency component has to be minimized in the filter, the PLL should allow for a relatively long lock time. Here, the largest frequency change of the local oscillator (45.150 MHz to 77.000 MHz) takes about 100 ms. Using the single-ended 'PDOUT' terminal of the MC14156-2 allows the loop filter to be kept simple. The MC33171 is used here because it is capable of supplying a rail-to-rail swing of the output voltage. This is a must if the VCO based on FET T5 is to cover the required frequency range (theoretically, 45.15 MHz to 77 MHz) without 'dying' as a result of a low varicap control voltage. In practice, the VCO is slightly overdimensioned, covering a frequency range of 37-85 MHz with a control voltage of 0-9 V. The VCO output signal is capacitively coupled to the first mixer (T2) as well as to a buffer stage around T6, which is designed to drive the ECL inputs of the MB501L divider chip.

IF amplifiers, AM/FM demodulators and SSB detector

Referring back to the block diagram, the good news is that all sub-circuits between the first IF filter and the output of the last IF amplifier are contained in a single IC, the TCA440. This old faithful from Siemens contains a preamplifier, an oscillator, an IF amplifier, and an AGC with a dynamic range of no less than 100 dB (which is no mean requirement for SW listening). The two 455-kHz IF filters for narrow (3 kHz BW) and wide (12 kHz BW) reception are connected into and out of the TCA440 external circuitry by means of PIN diodes and control signals supplied by the microprocessor. Other filters than the Toko types indicated here may be used as long as their input impedance is 2.2 kΩ, and the respective 3-dB bandwidths are about 3 kHz (narrow) and 12 kHz (wide). The TCA440 drives the S-meter directly via its AGC output. Meters with different sensitivities are accommodated with preset P3.

The injection signal for the second mixer is supplied by the oscillator inside the TCA440. This oscillator only needs an external quartz crystal and a couple of passive parts to supply a rock-steady 44.545 MHz signal.

The SSB detector is built around the familiar NE612 (or NE602), which contains a balanced mixer and an oscillator. The latter is connected to an inexpensive 455-kHz ceramic filter which is 'pulled' by a varicap, D23. The resulting deviation of about ±2 kHz is sufficient for USB and LSB reception (upper/lower sideband) if you turn the BFO control pot.

The FM demodulator is a classic ratio detector with a FET amplifier in front of it. This detector has been designed to supply enough output even if an NBFM (narrow-band frequency modulation) signal is received. NBFM is commonly used in the 27-MHz (11-m) CB band.

The AM demodulator consists of a single diode, D20, which also supplies the AGC drive signal.

The three tuneable inductors in this part of the circuit are all 455-kHz, ready-made types from Toko. These units contain internal tuning capacitors. Other 455-kHz transformers than the ones shown here may be used, as long as the primary-to-secondary turns ratio is 20:1 (in case of L14 and L18), and the tap is exactly at the centre of the primary (in case of L19).

Audio signal sections

Three BS170 FETs are used as analogue switches, feeding either the FM, AM or SSB signal to filter/amplifier T10. The control signals at the gates of the FETs are, again, supplied by the microprocessor circuit. The audio bandfilter is designed for speech at radio communications quality, i.e., roll-off points are defined at 450 Hz and 3.3 kHz to keep out most unwanted noise, and in the case of SSB, neighbouring stations. The LM386 audio amplifier, finally, supplies about 1 watt into 8 ohms, which is good for a small external loudspeaker in your shack, or a pair of low-impedance headphones (preferred by veteran DXers).

MICROCONTROLLER SECTION

The schematic of the microcontroller section in the receiver is given separately in **Figure 3**. This circuit also contains most of the power supply components.

The microcontroller used is the familiar PC16F84 from Microchip. Here, it executes a user program of about 1 kBytes from its on-chip ROM. The PIC controller is supplied ready-programmed by the Publishers.

The on-chip EEPROM is used to store and retain frequencies. Because the processor clock does not have to be particularly stable or accurate, the cheapest clock option, an R-C network (R1-C1), is used. The processor runs at about 4 MHz, however, it is only 'active' when its action is required, for example, when a key is pressed, or the synthesizer has to be reloaded. To keep spurious signals to a minimum in the receiver, the PIC will be 'asleep' most of the time!

Three of the four shift registers type 4015 expand the I/O functionality of the PIC into a 12-bit shift register which is used to drive the keyboard and the LCD. The keyboard is not a matrix type. As indicated by the circuit diagram, each switch has a separate connection, while the other goes to a 'common' rail. Pressing a key causes an interrupt which serves both as a wake-up call and a service request for the 'sleeping' processor. Turning the rotary encoder also generates a hardware interrupt and causes the processor to wake up. The encoder used here is a Bourns type with 24 turns per full rotation. It enables the complete tuning range of the receiver to be covered — just keep turning until the LCD shows the desired frequency, and then carefully adjust the preselector for best reception. Alternatively, type the desired start frequency into the keypad, and tune from there. The rotary encoder is connected directly to two PIC I/O pins. Debouncing is effected by hardware and software.

The remaining I/O pins of the PIC are used to control the serial synthesiser (RB5, RB6, RB7), and the preselector, by way of decimal counter IC2 (RB2, RB3).

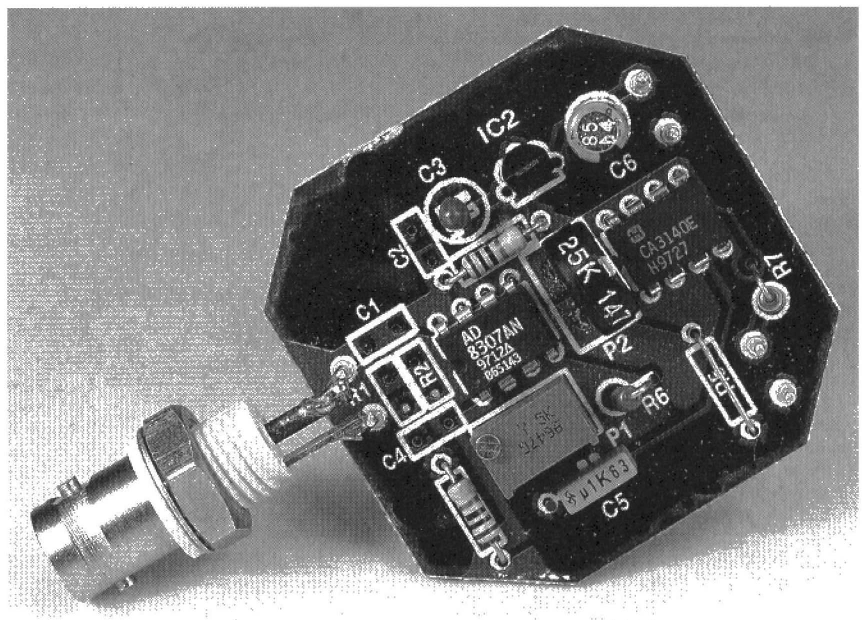
The power supply is conventionally based on 3-pin fixed voltage regulators from the 78 and 78L series. Three voltages are supplied: 12 V, two times 5 V, and 9 V. The latter and one of the 5-V supplies are part of the main receiver circuit discussed above (refer back to Figure 2). They obtain their input voltage from the 12-V regulator on the microprocessor board. The heaviest loads on the 12-V rail are obviously the audio power amplifier IC, the S-meter lighting and the LCD backlight (if used). The unstabilized input voltage should be at least 15 V. An inexpensive power mains adaptor may be used, but do note that the receiver may draw up to 450 mA, so go for a relatively powerful adaptor.

(980084-1)

The construction, adjustment and operation of the receiver will be discussed in next month's concluding instalment.

RF decibel meter

wideband with large measuring range



Some parameters

Frequency range	*100 kHz – 110 MHz with an error <1 dB*
	100 kHz – 200 MHz with an error ≤ 2 dB
Decibel range	*32 – 117 dBμ with an error at 10 MHz ≤ 1 dB*
Scaling	*10 mV dB^{-1}*
Input impedance	*50 Ω*

An RF decibel (or power) meter is an indispensable instrument in any radio workshop. Unfortunately, accurate, wideband models are fairly expensive, and home-constructed ones are generally not sufficiently sensitive and/or are very temperature-dependent. These drawbacks are overcome by a device from Analog Devices which has recently become available: a low-cost DC–500 MHz, 92 dB logarithmic amplifier that enables an accurate, not too expensive RF decibel meter to be constructed. A few small modifications make the meter also suitable for low-frequency measurements.

Design by P. Bolch

CIRCUIT DESCRIPTION

The circuit diagram of the decibel meter in **Figure 1** stands out by its simplicity, which is due to the Type AD8307 monolithic demodulating logarithmic amplifier, IC_1, from Analog Devices.

The measurand (quantity to be measured) is applied to pin 8 (INP) of IC_1 via input socket K_1 and capacitor C_1. The capacitor ensures that no direct voltage can reach the IC. The second input of the IC, pin 1 (INM) is linked to the earth line via capacitor C_4. The values of C_1 and C_4 are chosen to give a lower limit of the frequency range below 100 kHz.

Resistors R_1 and R_2 ensure that the input impedance of the meter is the usual value in RF equipment of 50 Ω. A parallel network is used to minimize any parasitic properties of the resistors. It is recommended to use SMT (surface mount technology) resistors.

Since the resistors are in parallel with the input terminals, any direct voltage present on the input signal will cause a potential drop across them. If this causes a problem, a coupling capacitor of about 0.02 µF may be inserted between the input socket and the resistors, but this will restrict the frequency range to about 30 MHz.

The output of IC_1 is essentially a current that causes a potential drop across a 12.5 kΩ internal resistor which is available at output pin 4. Series network R_6-P_1 is in parallel with the internal resistance to modify the scale factor, which is 25 mV dB^{-1} in the absence of an external circuit.

Capacitor C_5 averages the output signal to ensure a stable display. Its value depends on the application: a larger capacitance gives a more stable, but slow, display; a smaller value is recommended for fast sweeping.

Preset P_2 permits parallel shifting of the characteristic to give an attenuation of up to 14 dB or an amplification of up to 26 dB between the input socket and pin 8 of IC_1, provided that R_5 = 0. Resistor R_5 provides a narrowing of this preset range.

The purpose of resistor R_4 is to decouple the output of IC_1 from the remainder of the circuit and so enhance the response ratio of small signals.

Owing to the high output impedance of IC_1, buffer amplifier IC_3 is essential to enable a low-impedance load such as a moving-coil meter to be linked to the circuit.

Regulator IC_2 ensures a stable supply line for IC_1. Low-pass filter R_3-C_2 reduces any interference on the supply line.

A small modification enables the circuit to be used as a low-frequency decibel meter. Resistors R_1 and R_2, as well as capacitors C_1 and C_4, are then not used. Instead, pin 8 of IC_1 is linked via a parallel network of a 10 µF, 10 V tantalum capacitor and a 4.7 kΩ resistor in series with a 680 pF capacitor to the input socket, while pin 1 is connected to earth via an identical series-parallel network. Also, capacitor C_5 must be replaced by a 1 µF, 10 V tantalum capacitor (+ve terminal to pin 4). Finally, a 1 µF, 10 V tantalum capacitor must be fitted between pin 3 of IC_1 (+ve terminal) and earth. When this modification is carried out, the meter is no longer usable as an RF decibel meter, of course.

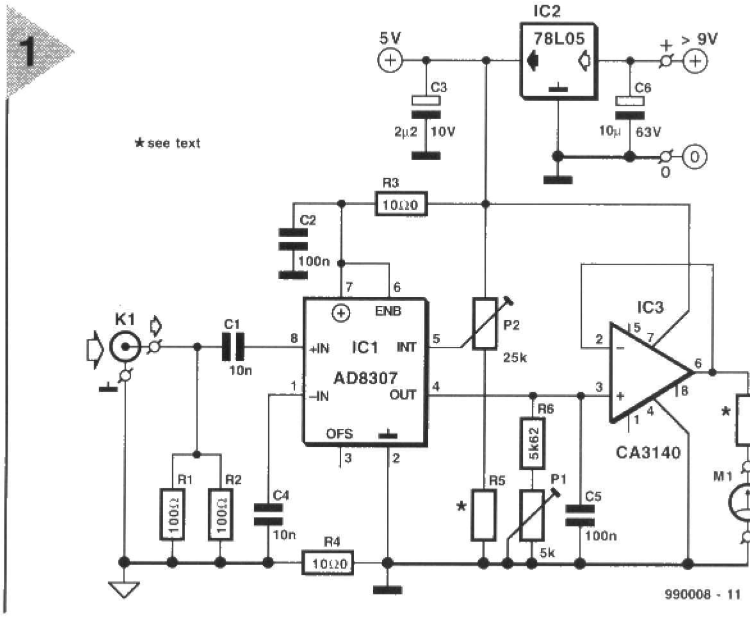
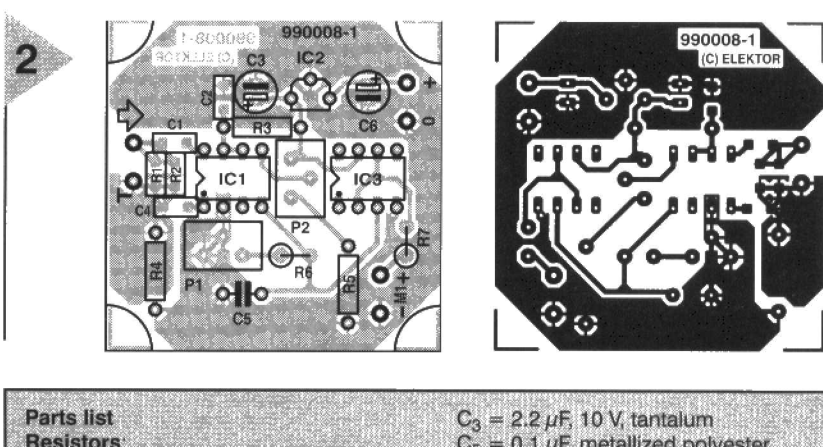


Figure 1. The circuit diagram of the decibel meter is centred on the AD8307 from Analog Devices.

DISPLAY

The display may be a digital multimeter, but, although this is accurate, it is not

Figure 2. The decibel meter is best built on this printed-circuit board which is, however, not available ready made.



Parts list

Resistors:
R_1, R_2 = 100 Ω, SMD
R_3, R_4 = 10.0 Ω
R_5, R_7 = see text
R_6 = 5.62 kΩ
P_1 = 5 kΩ (4.7 kΩ) multiturn upright preset potentiometer
P_2 = 25 kΩ multiturn upright preset potentiometer

Capacitors:
C_1, C_4 = 0.01 µF, SMD
C_2 = 0.1 µF, SMD
C_3 = 2.2 µF, 10 V, tantalum
C_5 = 0.1 µF, metallized polyester
C_6 = 10 µF, 63 V, tantalum

Integrated circuits:
IC_1 = AD8307AN (Analog Devices)
IC_2 = 78L05
IC_3 = CA3140E

Miscellaneous:
K_1 = 50 Ω BNC socket for board mounting
Enclosure

3

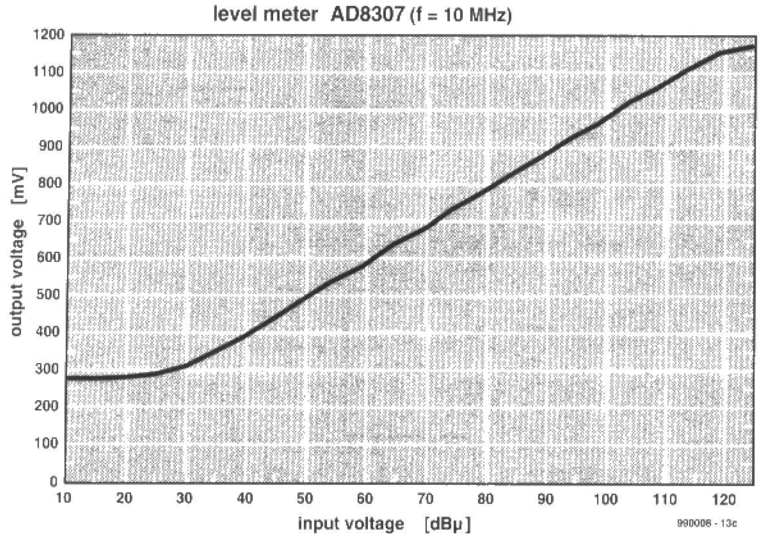


Figure 3. Transfer characteristic of the decibel meter at 10 MHz.

Level (dBμ)	Level (dBm)	$U_{o(10\ MHz)}$ (mV)	$U_{o(110\ MHz)}$ (mV)
10	–97	281	282
15	–92	282	283
20	–87	285	285
25	–82	294	294
30	–77	312	313
35	–72	353	356
40	–67	397	400
45	–62	450	450
50	–57	497	496
55	–52	550	544
60	–47	596	590
65	–42	650	641
70	–37	695	686
75	–32	750	737
80	–27	795	783
85	–22	847	833
90	–17	895	881
95	–12	948	933
100	–7	994	980
105	–2	1049	1033
110	+3	1090	1078
115	+8	1143	1132
120	+13	1185	1178
125	+18	1218	1188

The output at 200 MHz for an input of 99 dBμ is 948 mV
The output at 300 MHz for an input of 100 dBμ is 942 mV

easily calibrated.

A moving coil metering network with series resistor R_7 facilitates recognizing any drift such as encountered, for instance, during calibration, but does not make reading it easy.

Measurements with sweep frequencies can, of course, be displayed on an oscilloscope.

The decibel meter outputs a direct voltage that is directly proportional to the input signal. The display is calibrated in dBμ (decibel referred to 1 microvolt). The scale factor is 100 mV dB^{-1}, so that an input signal of 100 dBμ results in an output voltage of 1 V.

CONSTRUCTION

The meter circuit is best built on the printed-circuit board shown in **Figure 2**, but this is not available ready made. As mentioned earlier, some of the components should be SMDs (surface mount devices) as specified in the components list. If the circuit is constructed on prototyping board, standard components may, of course, be used. Keep all wiring as short as possible, however.

If operation up to 30 MHz only is needed, IC_1 may be inserted in a socket, but for use at higher frequencies the circuit should be soldered directly on to the board. This is best done after all other components have been fitted and the board has been checked thoroughly. This measure is to protect the AD8307, since this is not a cheap component.

Since the meter is an RF unit, it is clear that it should be fitted in an earthed metal enclosure. The power supply should, of course, not be fitted in the same enclosure. Another important aspect is that the 9–15 V supply voltage should be 'clean'. It is advisable to use feedthrough capacitors at the power line inputs and measurement output.

CALIBRATION

The meter circuit should be calibrated with a suitable RF signal generator or, in an emergency, an AF signal generator with calibrated attenuator.

Apply a signal at a frequency of 10 MHz and a level of 60 dBμ (1 mV r.m.s.) to the input of the meter circuit. Using a digital multimeter, measure the voltage at pin 3 of IC_3, increase or reduce the output of the signal generator by exactly 10 dB and turn P_1 to cause a change in the multimeter reading of 100 mV. The absolute value of the output voltage is not significant.

Next, apply a signal at a level of exactly 60 dBμ to pin 8 of IC_1 and turn P_2 until the meter indicates 600 mV.

If the requisite equipment is available, the calibration process can be repeated at a number of frequencies for greater versatility of operation.

If a signal generator is not to hand, adjust P_1 until the resistance between its wiper and earth is 1383 Ω measured with a digital multimeter. Finally, adjust P_2 to obtain a voltage of 1.627 V at pin 5 of IC_1, again measured with a digital multimeter.

SOME PROPERTIES

Figure 3 shows the transfer characteristic of the decibel meter at 10 MHz. The measurement range with an error smaller than 1 dB extends from about 30 dBμ to around 115 dBμ. Over a large part of this range, the error stays well below 0.5 dB. The error rises rapidly outside the measurement range, which is typical of the conversion process in IC_1.

When the frequency is increased

(the well-calibrated prototype can be used up to 110 MHz), the transfer characteristic shifts slightly downwards, but retains the linearity shown in Figure 3. A number of characteristic values at 10 MHz and 110 MHz are given in Table 1.

If measurements over only a limited range are needed, the frequency-dependent slight shift of the transfer characteristic may be negated during the calibration so that a slightly more precise meter reading is obtained.

Measurements carried out with the prototype at frequencies of 200 Mhz and 300 MHz at a stable input level of 100 dBμ show that the circuit may be used without any problem at these frequencies.

[990008]

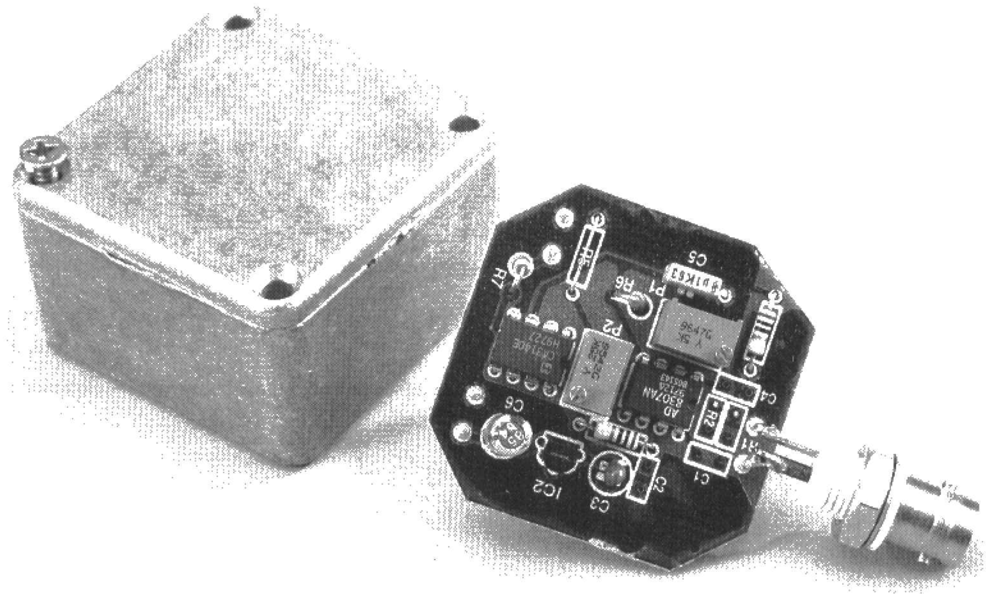


Figure 4. The finished prototype decibel meter.

AD8307

The Type AD8307 monolithic logarithmic amplifier is intended for a number of applications, among which

- *Conversion of signal level to decibel form*
- *Transmitter antenna power measurement*
- *Receiver signal strength indication (RSSI)*
- *Network and spectrum analysers (up to 120 dB)*
- *Signal level determination down to 20 Hz*
- *True decibel AC mode for multimeters*

Its operation is based on the progressive compression (successive detection) technique, providing a dynamic range of 92 dB to ±3 dB law-conformance and 88 dB to a tight ±1 dB error bound at all frequencies up to 100 MHz.

The device is very stable and easy to use. It needs a supply voltage of 2.7–5.5 V at 7.5 mA, corresponding to a low power consumption of 22.5 mW at 3 V. A fast-acting CMOS-compatible control pin can disable the AD8307 to a standby current of not more than 150 µA.

Each of the cascaded amplifier/ limiter cells has a small signal gain of 14.3 dB with a –3 dB bandwidth of 900 MHz. The input is fully differential at a moderately high impedance (1.1 kΩ in parallel with 1.4 pF).

The device provides a basic dynamic range extending from about –75 dBm (decibel referred to 1 mW) to around +17 dBm. A simple input-matching network can lower this range to –88 dBm to +3 dBm. The logarithmic linearity is typically within 0.3 dB up to 100 MHz over the central portion of this range, and is degraded only slightly at 500 MHz. There is no minimum frequency limit: the AD8307 may be used at audio frequencies down to DC.

The output is a voltage-scaled 25 mV dB^{-1}, generated by a nominal current of 2 µA dB^{-1} through an internal 12.5 kΩ resistor. This voltage varies from 0.25 V at an input of –74 dBm (that is, the a.c. intercept is at –84 dBm, a 20 µV r.m.s. sinusoidal input), up to 2.5 V from an input of +16 dBm. This slope and intercept can be trimmed with external adjustments. For instance, with a 2.7 V supply, the output scaling may be lowered to 15 mV dB^{-1} to permit utilization of the full dynamic range.

The AD8307 has good supply insensitivity and temperature stability of the scaling parameters. The combination of low cost, small size, low power consumption, high accuracy and stability, large dynamic range, and a frequency range from DC to UHF make it useful in numerous applications requiring the conversion of a signal to its decibel equivalent.

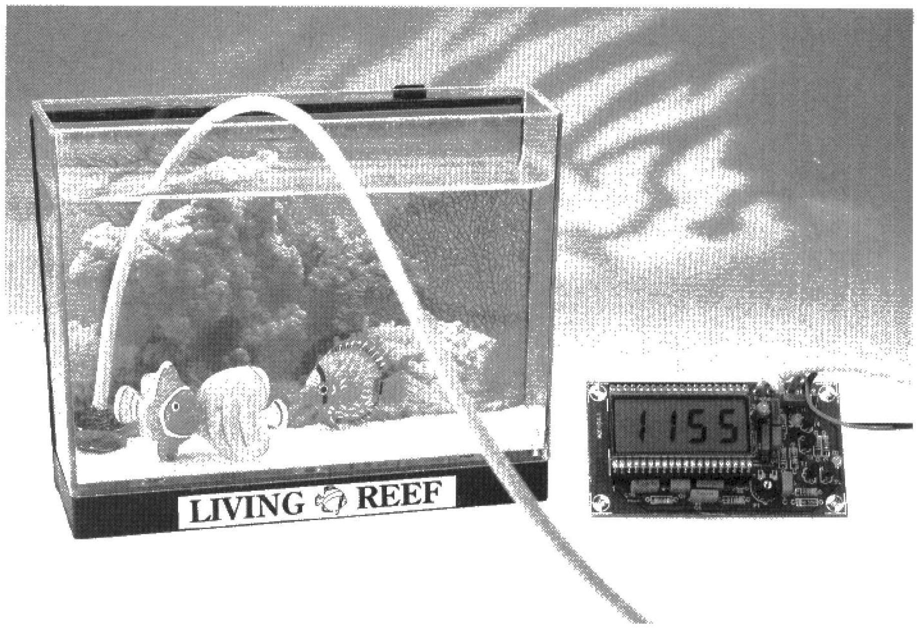
Further information on the Internet: www.analog.com/AD8307

conductance tester

with DIY sensor

Conductivity in the sense it is used in this article is the ability of a substance such as water to conduct electric current. It is expressed in terms of current per unit of applied voltage. It is the reciprocal of resistivity. Conductance is the reciprocal of resistance and is measured in siemens. It is therefore the ratio of the current through a substance to the potential difference at its ends.The tester described in this article is intended for assessing the quality of water, based on the acidity or alkalinity (pH), by means of a measurement of the conductance of the water.

Design by P. Baer



INTRODUCTION

Water with a very high pH is not good for fish, plants or making tea or coffee. This is the reason that many aquarium owners, orchid growers, horticulturists, and many others use distilled or filtered water. Water filters are very popular in domestic use, where the quality of tap water is suspect. However, water filters themselves present a risk of germination, requiring good attention to cleanliness (bottle needs thorough washing at least once a week).

A very environment-friendly way of obtaining low-pH water is the use of rainwater, but this depends heavily on the area where the rainwater is collected. Such water may be tested for low pH, that is, low conductivity, with the present tester.

The pH of water is a logarithmic index of the hydrogen-ion concentration in the water. It is given by

$$pH = \log_{10}(1/[H^+])$$

where $[H^+]$ is the hydrogen-ion concentration. A pH below 7 indicates acidity and one above 7, alkalinity, at 25 °C.

CONDUCTIVITY AND CONDUCTANCE

Conductivity (or specific conductance), being the reciprocal of resistivity, is measured in the same way as resistance and expressed in S m^{-1} (siemens per metre); its symbol is σ. At constant temperature, the value of conductance, symbol G, of a substance depends on the cross-sectional area, A, in m^2, the length, l, in m, and the conductivity, σ, in S m^{-1}:

$$G = \sigma A/l. \qquad \text{S (siemens)}$$

This equation can be used with a solid as well as with a liquid substance.

The sensor used in the present tester consists of two annular electrodes having a cross-sectional area of 1 cm which are spaced 1 cm apart. These dimensions make the calculation of the conductance of the water being tested straightforward.

Pure water, sold as distilled water, as used, for instance, in electric irons, lead-acid batteries and for horticultural purposes, has a conductivity of 1×10^{-3} S m^{-1}, so that the present meter would

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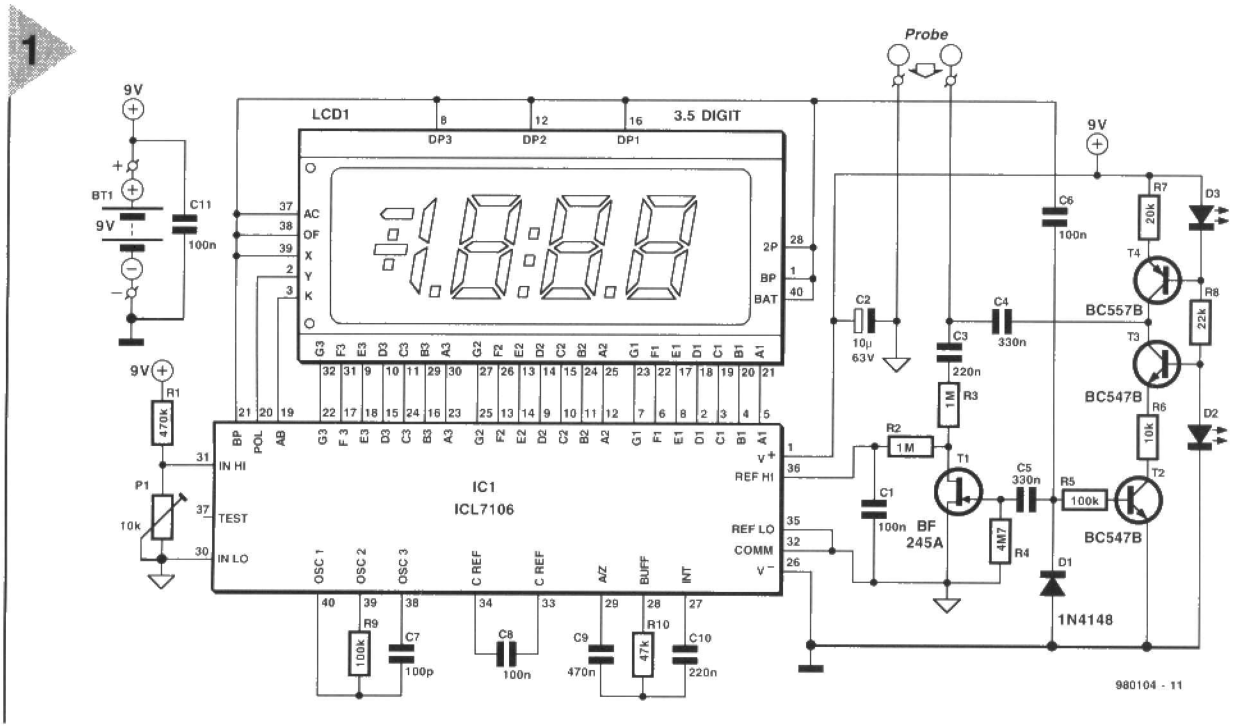


measure 10 μS (equivalent to a resistance of 100 kΩ). When the water becomes less pure, the resistance between the electrodes drops, and the value of conductance rises. Normal tap water has a conductance of about 1 mS, and sea water, 100 mS or more.

THE TESTER

From the above, it is clear that the tester must be capable of measuring resistance or conductance. This seems simple enough: take a constant current source, insert the sensor in a potential divider and apply the voltage across the sensor via an analogue-to-digital converter (ADC) to a suitable display.

Unfortunately, the reality is not so simple, since the resistance of a fluid must be measured with an alternating instead of a direct current. This is because a direct current would cause electrolysis which after a while would distort the sensor electrodes.

The tester, whose circuit diagram is shown in **Figure 1**, therefore uses a rectangular current. This enables the ADC to drive the liquid-crystal display (LCD) via pin 21, the backplane voltage terminal.

The backplane voltage is used to switch, via transistor T_2, constant-current sink T_3-D_2-R_6, which is combined with constant-current source T_4-D_3-R_7. Capacitor C_4 is charged and discharged in rhythm with the backplane voltage at a rate of 100 mA. Because of this arrangement, the 100 μA current from the source is absorbed by the sink when the capacitor is being discharged. Consequently, an alternating current of $\pm$100 μA flows through the tester, which causes a potential drop of $\pm$100 μV Ω^{-1} across the resistance, that is, the water.

The test voltage is taken from across R_2-R_3-C_3. During the negative half-period of the backplane voltage, transistor T_1 links the test voltage to earth. In essence, therefore, this FET operates as a clocked synchronous rectifier without a threshold voltage and consequent non-linearity.

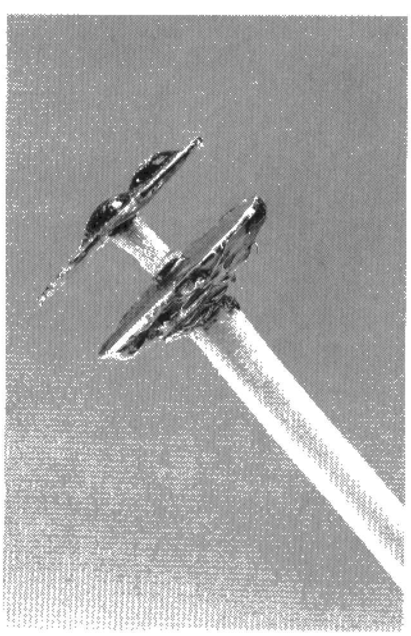
The direct test voltage so obtained is directly proportional to the resistance of the water. It must, however, be inverted to provide a test display in siemens. In the present circuit this is achieved by applying the test voltage to the reference voltage input (REF. HI)of IC_1 and a constant voltage to the test input pins (IN HI and IN LO). This results in the display showing U_c/U_T, instead of, as normal, U/U_{ref}. (U_c is the constant voltage across pins 30, 31, U_T is the test voltage, and U_{ref} is the reference voltage). Preset P_1 provides compensation for component and sensor tolerances.

Figure 1. Circuit diagram of the conductance meter.

THE SENSOR

To make the sensor, two rings of brass or other easily soldered metal, a 15 cm length of RG58U coaxial cable, and a heavy-duty soldering iron are needed. The brass rings should have an inner

Figure 2. Parts required for constructing the sensor.



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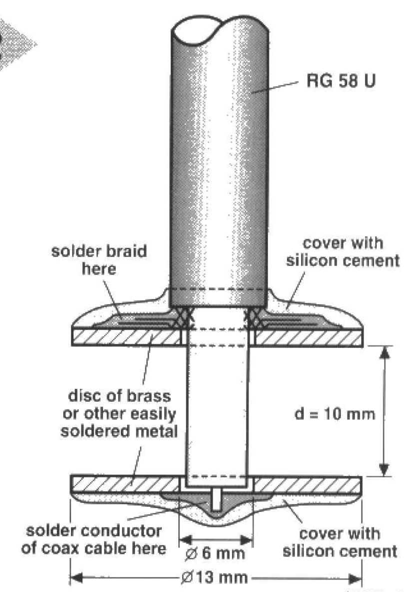

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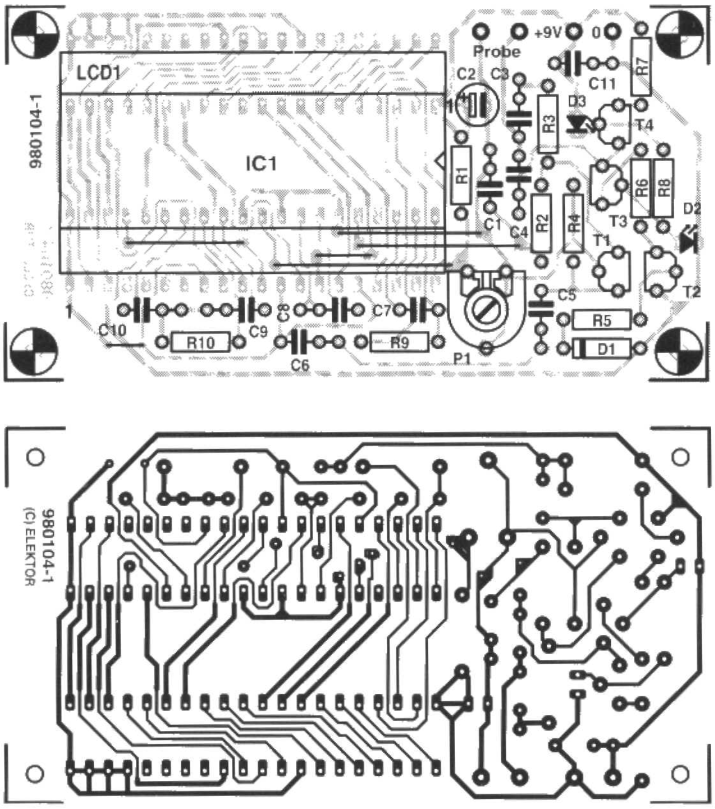


Figure 3. The printed-circuit board for the conductance tester.

diameter of 6 mm and an outer one of 13 mm to give them an effective area of just under 1 cm². The inner diameter allows them to just fit over the inner conductor of the coaxial cable, whose outer insulation must be removed over a length of about 15 mm from one end and 10 mm of the exposed braid cut off. The remaining 5 mm of braid must be folded back over the outer insulation of the cable. This ensures that the two brass rings are about 1 cm apart (see **Figure 2**). The inner core of the coaxial cable is then soldered to the outer brass ring and the braid to the inner ring. The outer surfaces of the rings (but not those facing each other) should then be covered with silicon cement.

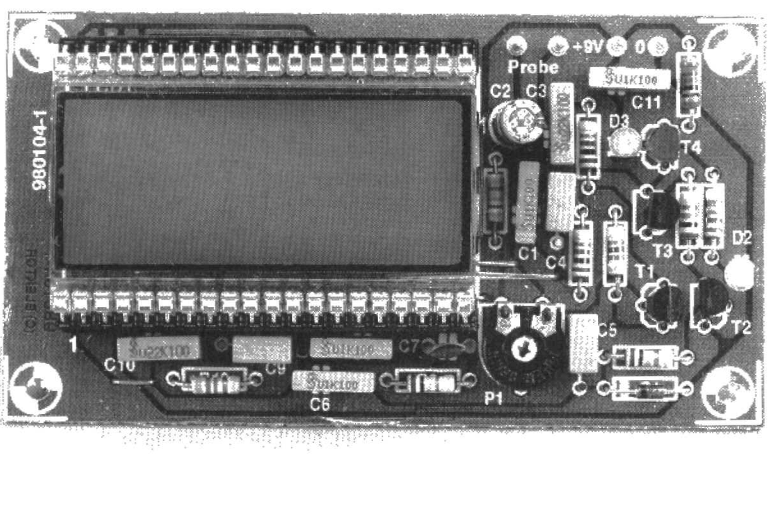
CONSTRUCTION

The remainder of the tester is best constructed on the printed-circuit board shown in **Figure 3**. Mind the polarity of the diodes and electrolytic capacitors. The IC should be soldered directly to the board to allow the display to be fitted directly above it.

Connect a standard potentiometer across the test inputs and check that the display shows corresponding conductance values when the potentiometer is turned from, say, 10 kΩ to 1 kΩ.

When all is well, fit the completed board into a suitable enclosure in which a cut-out for the display has been provided. Connect the sensor to the probe terminals as shown in **Figure 4**. Do not forget an on/off switch.

Figure 4. The completed prototype board.



FINALLY ...

The tester has a range of 50 μS, which corresponds to a resistance of 20 kΩ and a maximum test voltage at IC_1 of 2 V. This value will be displayed when the tester, or rather, the sensor, is dry. The upper limit of the test range (1999 μS) is set by the characteristics of IC_1. Note also that the basic error of 5 per cent increases slightly when the test range is given an upper limit of more than 1000 μS. [980104]

Parts list

Resistors:
R_1 = 470 kΩ
R_2, R_3 = 1 MΩ
R_4 = 4.7 MΩ
R_5, R_9 = 100 kΩ
R_6 = 10 kΩ
R_7 = 20 kΩ
R_8 = 22 kΩ
R_{10} = 47 kΩ
P_1 = 10 kΩ preset potentiometer

Capacitors:
C_1, C_6, C_8, C_{11} = 0.1 μF
C_2 = 10 μF, 63 V, radial
C_3, C_{10} = 0.22 μF
C_4, C_5 = 0.33 μF
C_7 = 100 pF
C_9 = 0.47 μF

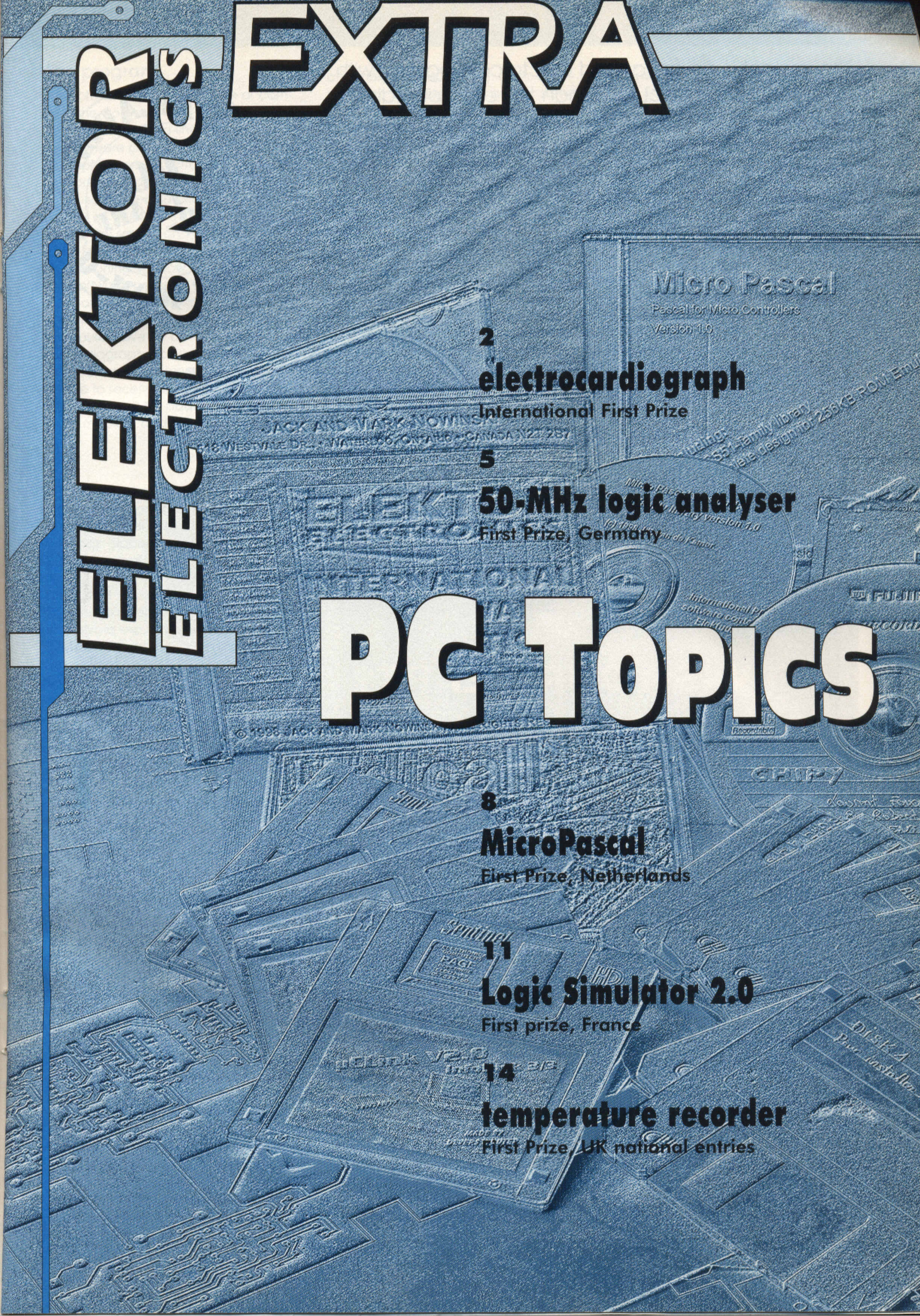
Semiconductors:
D_1 = 1N4148
D_2, D_3 = LED, green, 3 mm
T_1 = BF254A
T_2, T_3 = BC547B
T_4 = BC557B

Integrated circuits:
IC_1 = ICL7106CPL (Maxim)

Miscellaneous:
LCD_1 = 3.5 digit liquid-crystal display (note that IC_1 and LCD_1 are available as a set)
BT_1 = 9 V dry battery with clip
1 off switch with on contact
Enclosure as appropriate
PCB Order no. 980104-1 (see Readers Services towards the end of this issue)

Conductivity at 20 °C

Silver	1.6 × 10^{-8} S m^{-1}
Copper	1.7
Aluminium	2.8
Tungsten	5.6
Nickel	6.8
Iron	10
Steel	18
Manganin	44
Carbon	3500



ELEKTOR ELECTRONICS EXTRA

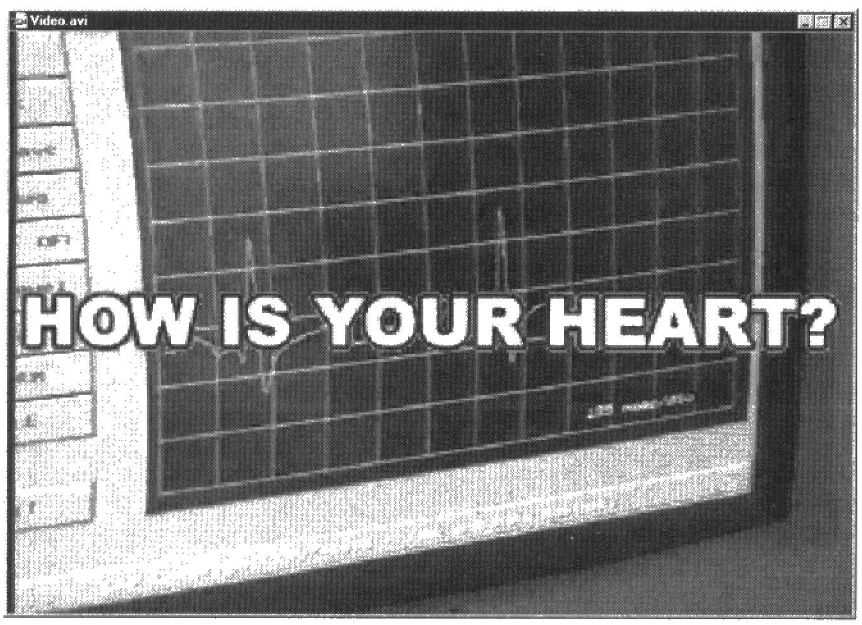
PC TOPICS

The project is an advanced electrocardiograph with a much greater accuracy than the electrocardiographs used in most of the world's hospitals today. Remarkably, the project allows patients to record their own ECG at home, and send the relevant data to the doctor's office by modem.

By Jack and Mark Nowinski

electrocardiograph

International First Prize



The project, which involves both hardware and software, covers all the three themes of the International PC Software Competition: *measurement*, *development*, and *communications*.
The software is the most instrumental tool used in the project on account of the high accuracy it achieves through the use of signal transforms and real-time processing of the electrocardiogram signal supplied by the hardware unit.
As for the first theme, *measurement*, the software program is able to graph and analyze the full signal spectrum coming from the hardware unit. Through this analysis of the signal, the software program is able to measure very critical aspects of the electrocardiogram (ECG) such as the QRS complex, the frequency of the heartbeat and the number of beats per minute (no electrocardiograph in the world has such a feature built into one device). Due to the powerful instruction set of fourth and fifth generation of Intel x86 processors, the mathematical transforms used for the measurement of the signal enable the most accurate electrocardiograph in the world to be created.
This project is full of *development*; firstly the hardware and software were designed and developed from scratch. A lot of development tasks took place both on the software and the hardware. Development will always be ongoing on account of the software, which has the ability to create databases for people (patients) using the electrocardiograph described here.
Also, the hardware is has been designed to be expandable, and software function routines are provided to detect if the PC processor has MMX instructions for future portability and compatibility. In that way, the project can always take full advantage of the processor when needed.
As for *communication* there are two ways this project communicates with the outside world, (1) through a printer port (parallel port), and (2) through a modem. The control program communicates with the electronic hardware via the printer port in which data is sent rapidly in a bi-directional fashion between the computer and the electronic hardware. Through the printer port the software is able to control the entire electronic hardware. The second way in which the program communicates with the outside world is through a modem. The project is primarily intended to be used by people in their homes. A heart patient with a computer at home would apply the standard medical electrodes to his/her body and be able to transmit his/her ECG to a doctor's office so the doctor would then be able to study the ECG and determine if medical help is needed. The ECG signal can be transmitted in real-time over the modem and accurate up-to-date information can then be processed by a medical doctor, the software program itself has the capability for medical analysis.

The program

The software used to produce or compile the software was Borland C++ version 5.01 (with in-line assembly).
The software program is based around a graphical-user-interface (GUI) of the authors' own design, see **Figures 1a-d**. All software operations take place mainly in the menu on the left-hand side of the screen and some measurement specific operations take place in the graphing window. The function of the software program is to graph an ECG on the screen and if necessary transmit it to a doctor's office (the doctor would have to be using the electrocardiograph software program to receive the ECG signal). The program is able to receive data from two channels (more can be added, but for standard medical and home use one/two channel(s) are sufficient). Both channels can be displayed at the same time, while one may be detecting the so-called QRS complex in the ECG, the other can detect other arrhythmia's.
Another first for an electrocardiograph is the use of a TIME BASE for an accurate interpretation and analysis of the ECG signal. The other options, X-MAG, TRIGGER, MODEM and FILE are described in the interactive multimedia presentation on the CD-ROM supplied (see end of article). To summarize, the X-MAG even further divides the time base setting by constant integer dividers, the TRIGGER control button sets the triggering level and MODEM control button initializes the modem (along with the telephone number to be called) and tells the program to transmit the ECG over the telephone line. In FILE you can open and save ECG files and thus help to build a database that could be used in the future by a medical doctor. The entire graphics library used by the program had to be written from scratch, and the authors also had to configure the interrupts for the printer port and initialize various types of modems and their protocols. In summary, the function of the software program is to graph incoming ECG signals (from the hardware unit through the printer port), and perform a very intense analysis of the signal and finally save the waveform and/or transmit it to a doctor's office; the software program measures the ECG signal, develops a database, and communicates with the outside world by transmitting the signal to a medical facility.

a
c
b
d

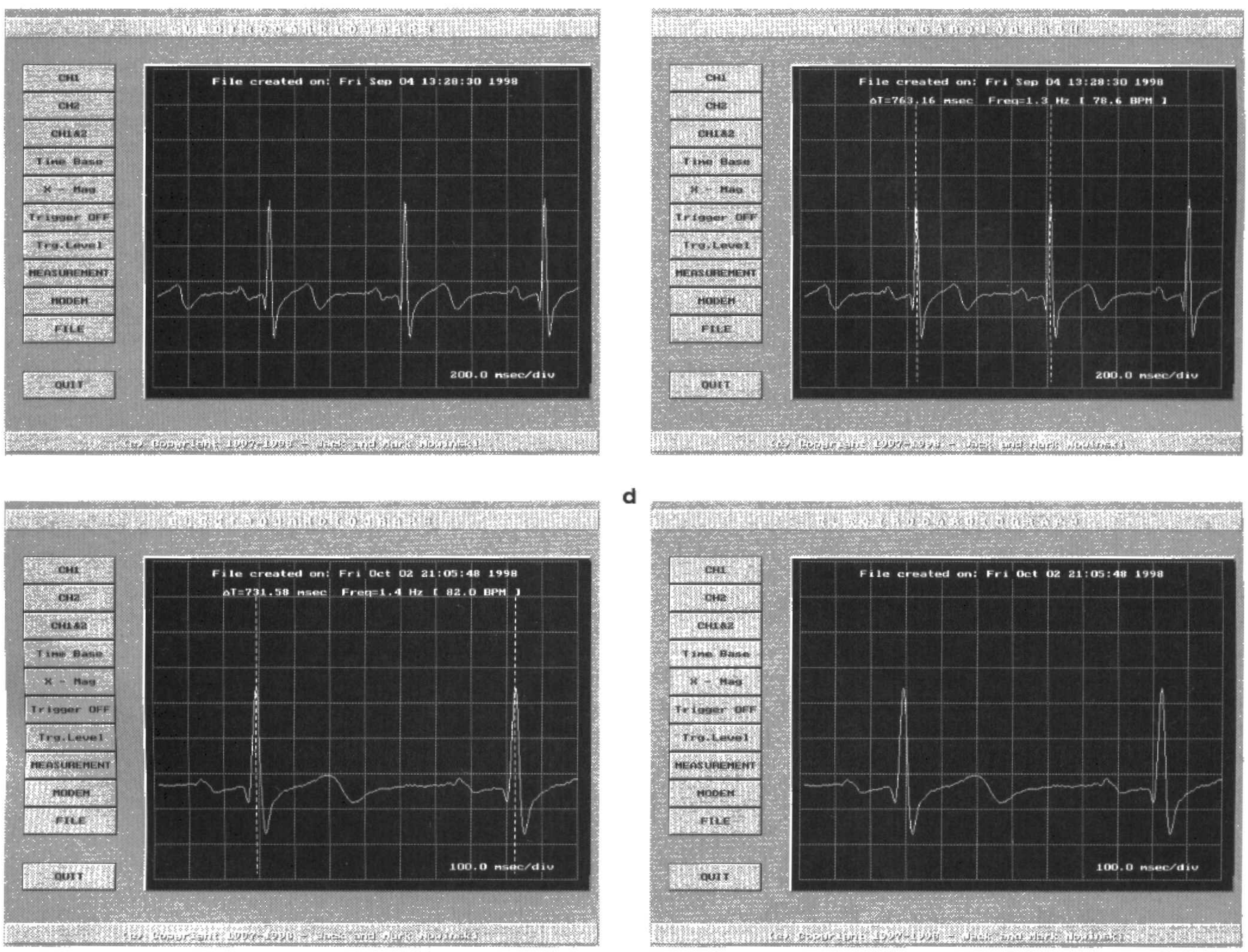


Figure 1a. This screenshot has the ECG waveform already plotted. The control buttons on the left manipulate how the incoming ECG signal is processed. For example, by clicking the right or left mouse button you can increase or decrease the time base on the grid.
Figure 1b. This screenshot is like the one above but has the measurement feature activated. The time base (lower right) is a factor when calculating the exact time (delta t).
Figure 1c. This screenshot shows the program operating under a different time base (100.0 msec/div).
Figure 1d. Measurement results for the image above. Notice that the peaks are farther apart on screen but the time base is utilized to produce an accurate measurement.

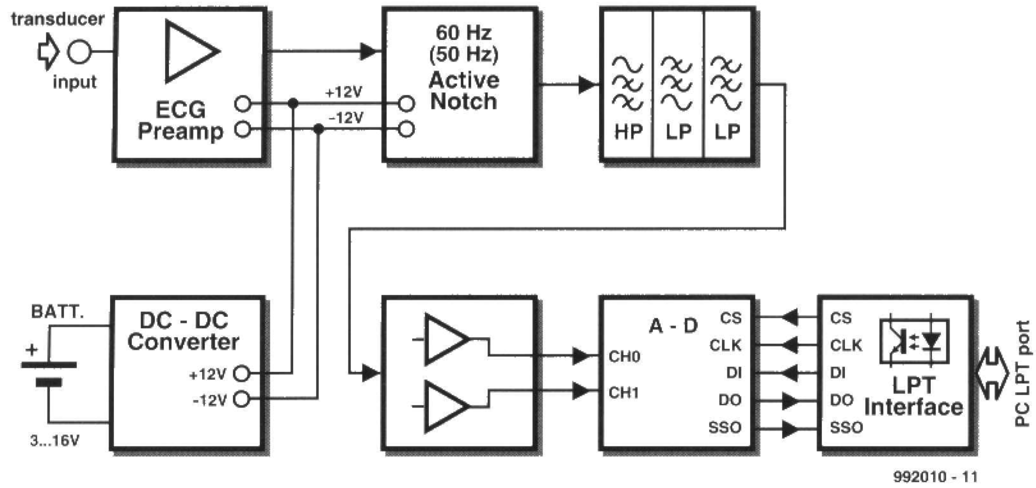


Figure 2. Block diagram of the electrocardiograph hardware.

The hardware

As shown by the block diagram in **Figure 2**, the hardware is composed of amplifiers, active filters, an analogue to digital converter, opto-isolators, and a DC/DC converter and inverter. A highly accurate low-pass and high-pass filter combination (active Butterworth Fourth-order filter) was designed and produced to eliminate the extraneous noise produced by power lines and skin movements under the electrodes. The filter combination has an extremely high roll-off rate thus making sure that the required frequencies are accepted and other unwanted frequencies are rejected. A DC/DC converter and inverter were designed and incorporated because certain integrated circuits require negative and higher voltages other than standard TTL voltages.

An analogue-to-digital converter (12-bit) is used to digitize the analogue ECG signal into the digital domain so the software program along with PC will be able to recognize it, this also improves the analysis of the signal later in the program. Opto-isolators are used to send the digitized signal from the hardware to the computer via the printer port (LPT); opto-isolators are need in this type of medical equipment to isolate the hardware supply voltage from that of the computer.

Unfortunately, owing to lack of space it is not possible to produce all schematics and PCB artwork for the hardware developed by the authors. The circuit diagram of the ECG input amplifier is, however, given as a sample in **Figure 3**. The inputs of this circuit are connected to standard ECG electrodes as demonstrated in Jack and Mark's wonderful video clip in which they describe the development and basic operation of their project. Well worth viewing!

(992010)

All software, source code files, schematic files, PCB artwork files and a demonstration video (AVI file) as supplied by the authors may be found on a CD-ROM which will be available from the Publishers by early January 1999.

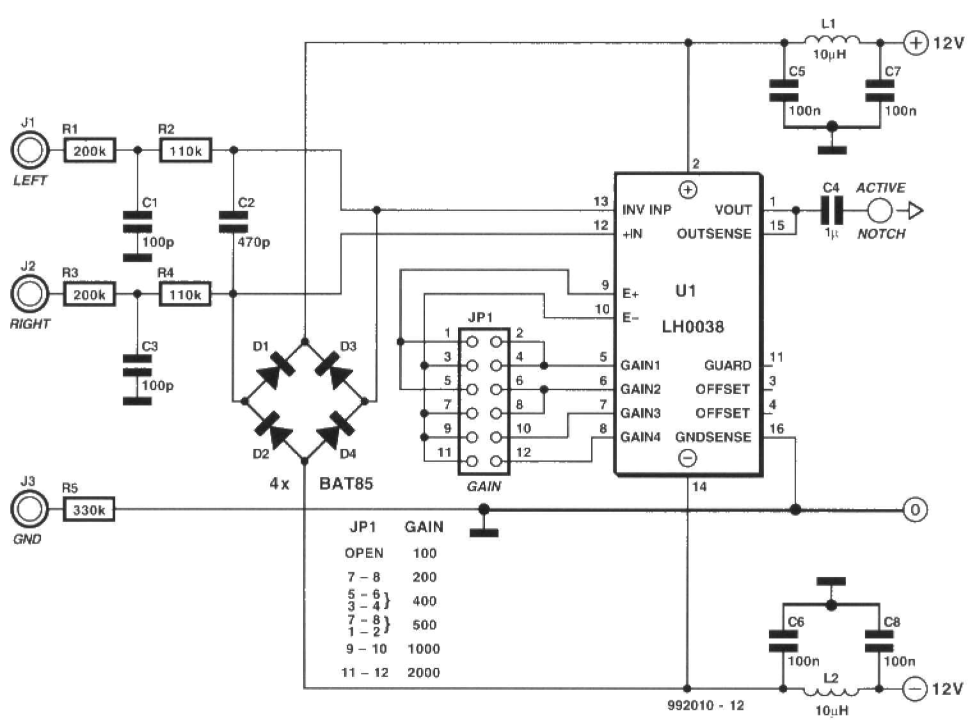


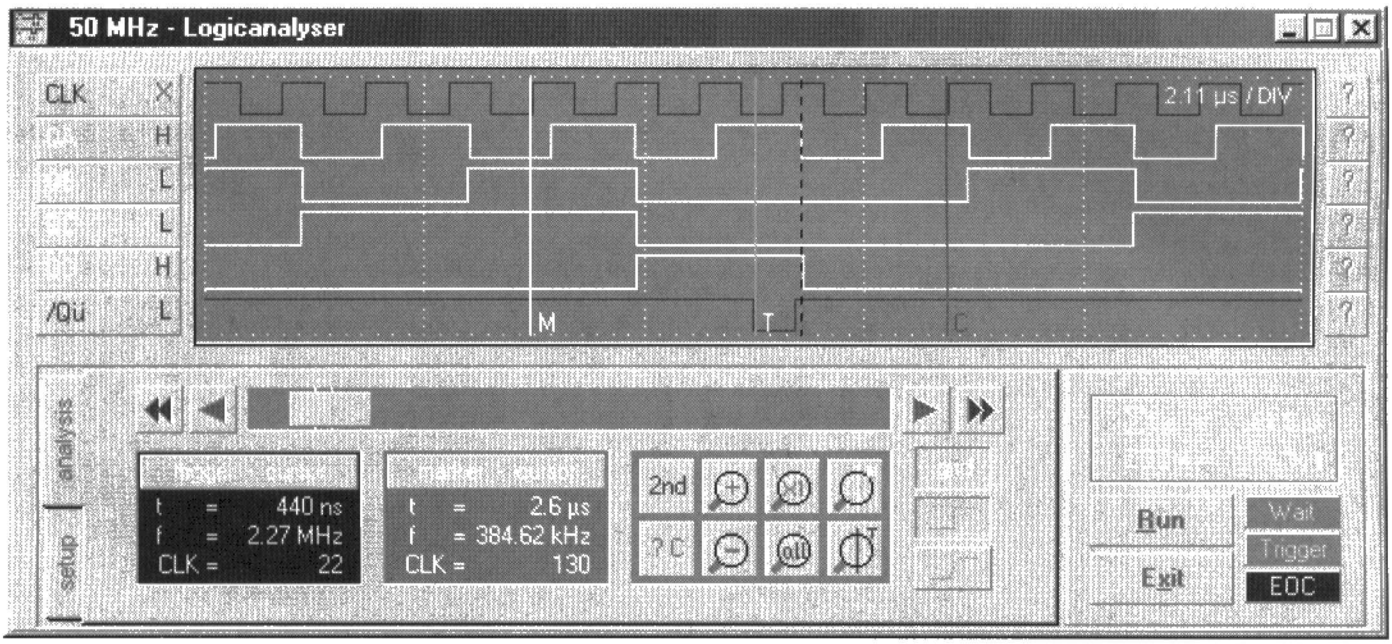
Figure 3. Circuit diagram of the ECG input amplifier. The circuit employs an LH0038 programmable-gain amplifier.

This professionally designed 16-channel logic analyser runs under Windows and is connected the PC's parallel printer port. It requires a minimum amount of hardware and costs a fraction of a comparable stand-alone instrument. A PC-controlled instrument, it offers ease of control and many ways of displaying measured signals.

Design by K. Böhme

50-MHz logic analyser

First Prize, Germany



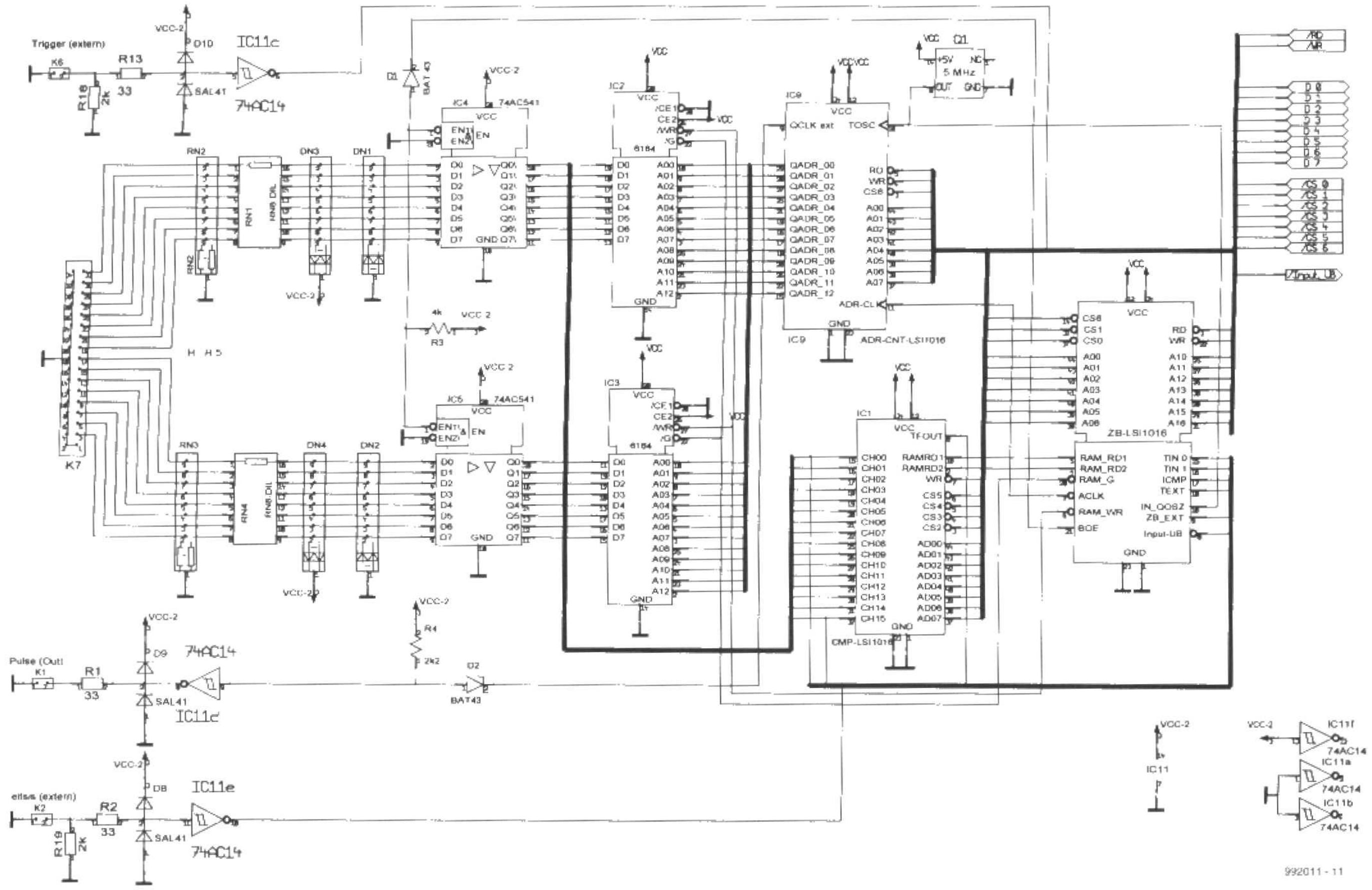
Main Specification

- Linked to computer via EP port (parallel printer interface)
- 16 channels (3 V or 5 V input swing)
- Sampling rate 1 kHz – 50 MHz (or by external clock up to 50 MHz)
- Adjustable pre-trigger from 1/8 to .7/8
- Triggering by CH00, CH15, adjustable bit pattern, or external
- Adjustable min. trigger pulsewidth from <=1, 4, 8, 15 samples
- Adjustable trigger edge
- Frequency output 10 Hz – 50 MHz
- Output level of frequency output 3 V or 5 V.

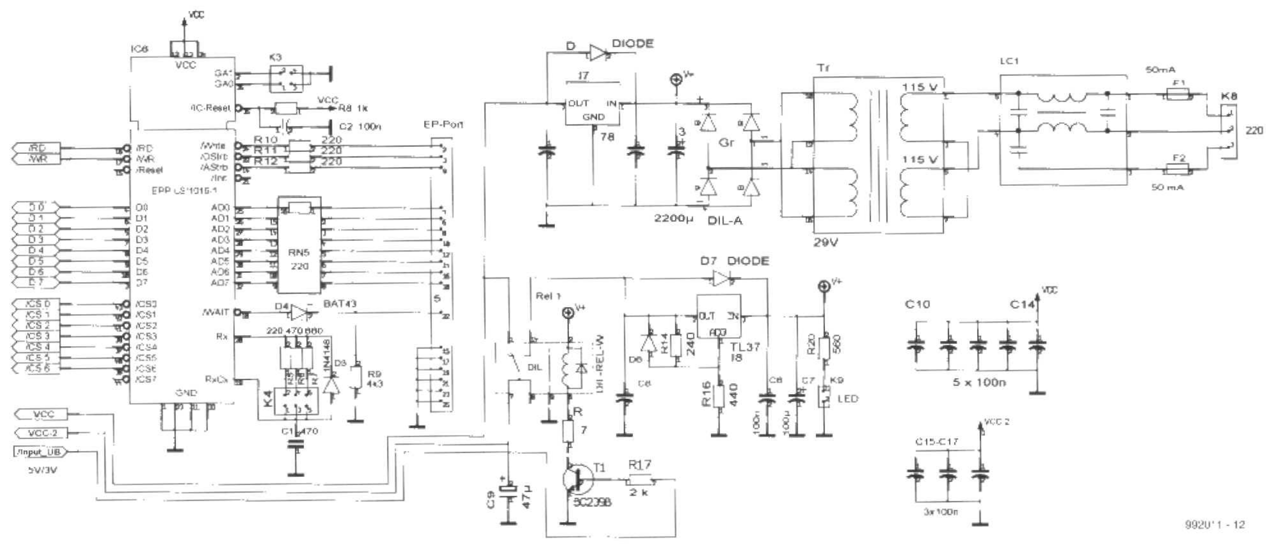
The instrument is controlled via a virtual front panel which appears on your PC screen. Apart from the customary user interface, the instrument offers all advantages of a PC running under Windows, including copying the read-out into temporary storage, and post-processing of measured data by other Windows programs.

The hardware consists essentially of four Lattice FPGA devices type ispLSI1016 from Lattice. These devices appear prominently in the circuit diagrams in **Figures 1 and 2**. Circuit IC6 in Figure 2 is busy handling all data traffic on the EP port. The device number (3 for the analyser) may be set on two jumpers (K3), and the delay for the wait signal, on jumper K4. The IC receives an address write command to inform it about the chip select line to be set. The relevant IC is then addressed by the subsequent data read or write command.

The heart of the analyser is formed by IC10. This chip contains the entire process control system consisting of a presettable 12-bit up/down counter



Figures 1 and 2. In essence the hardware of the Logic Analyser consists of four ispLSI chips from Lattice.



with decoding logic. At the start of a measurement, the pre-trigger value is loaded, and this is counted down to zero. Once at 00, the decoding logic disables itself, reverts the count direction, and then enables the trigger control. If a trigger pulse arrives at that instant, the counter is reloaded with the pre-trigger value, and counts up until an overflow is produced. It then disables itself, as well as the RAMs and their address counters. This concludes the measurement, and the data stored in the RAMs may be read by the system.

The same IC also contains the input multiplexers for the timebase, the trigger source selection logic, and the counter for the minimum trigger pulsewidth.

The control signals supplied by this subcircuit are:

- RAMRD_1: read RAM1
- RAMRD_2: read RAM2
- RAM_G: output enable for both RAMs

- ACLK: clock signal for address counter
- RAM_WR: write signal for both RAMs
- BOE: output enable for input drivers IC4/IC5
- Input_UB: goes to Re1 and there controls the voltage switchover for the input and output drivers (IC4, IC5 and IC11).

Circuit IC9 contains the dividers for the variable output frequencies, two multiplexers for their selection, and a 12-bit counter which acts as an address counter for the two RAMs.
IC1 contains an 8-bit multiplexer for the reading of the two RAMs, the storage registers for the set trigger word, and a comparator which pulls the TFOUT output logic high when the levels at the analyser inputs match those set up in the trigger word.
Circuit IC2 and IC3 are fast RAMs with a capacity of 8 kBytes each. The program uses about 4 kBytes, an extension to 8 kBytes is already supported by the PCB layout.
Circuits IC4 and IC5 are input drivers between the inputs and the RAMs. IC11 acts as a driver for the signals at the output sockets, and at IC10. Relay Re1 allows all driver ICs to work with 3.5 V or 5 V logic swing. Both supply voltages are provided by IC7 and IC8.

Software functions and documentation

The 32-bit control program (written in Visual BASIC V5) takes care of all hardware control and also provides an easy way of browsing the 4-kByte memory area. Further functions include setting two marker lines, outputting measurement values, and setting up trigger points and markers using at the mouse cursor location. You can jump to the marker lines by means of a mouse click.
Zooming is possible via 'buttons', while an area to be examined in detail may be enlarged by drawing a rectangle with the mouse.
Program settings as well as entire data files may be stored complete with comment, for retrieval at a later time.
For documentation purposes, the contents of the active window may be copies into temporary storage, from which it may be loaded by other programs including word processors.
All channels may be displayed in a certain colour and they may be given a name. To make sure the control elements and the actual data display are quickly available without having to jump between partly obscured windows, the windows are divided between two register cards (tabs), and displayed as fixed elements in a separate window which also contains the data display.
Apart from descriptions of the circuit diagram, the circuit operation and program installation (in a Word file), the documentation as supplied by the author also includes the actual circuit diagrams, the copper track layout and component mounting plan of the double-sided printed circuit board (in a TIFF file), as well as all source code files and sample data files which should enable you to check the operation of the program.
The complete set of documentation files and program files covering the use and installation of the program may be found on a CD-ROM which contains a large number of winning entries from our 1998 Software Design Contest. This CD-ROM will be available early January 1999. More details will be given in the forthcoming February 1999 issue of *Elektor Electronics*.

(992011-1)

CALL FOR PAPERS

Welcome to the first issue of Elektor Electronics, volume 1999! Technical authors and designers are now invited to contribute to the Autumn and Winter 1999 issues of Elektor Electronics, in which we plan to cover the following subjects:

- *Digitizing audio signals*
- *New battery and charging technologies*
- *New PC technology*
- *Digital medium and short-wave radio*
- *The 20th century in retrospect*

Advice on style, article size and technical requirements regarding text and illustrations (file formats, etc.) may be obtained from the Editor.

We also call for stories covering interesting topical subjects in the field of electronics and computers, as well as for reviews and construction projects with an extensive explanatory text. Some experience in writing is appreciated, but not essential (who knows, you could be a natural talent).
If you have recently finished an interesting construction project, write a text with it and send us the article. Preferably, the text and illustrations should be supplied on floppy disk. The same applies to reviews and topical stories.

Send your manuscript to

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If you would like to offer your free-lance writing services for assigned subjects, inform us (in writing) about your specialism or favourite interest, and any proposals you may already have. Even if your specialism is not mentioned above, we would still like to hear from you in view of other subjects to be covered next year.
Every article is judged by the editorial staff on the basis of its publication value. You will receive our verdict as soon as possible. If your article is of interest, you will also receive our conditions for publication.
This call is also addressed to companies having press releases and other interesting background information available on the subjects mentioned above.

The winning design among the Competition entries received by our Dutch sister magazine is a MicroPascal compiler for microcontrollers from Intel's MC51 series. The software enables these microcontrollers to be programmed in a simple way using the 'Pascal' higher programming language. Helped by a separate ROM emulator, MicroPascal may considerably reduce software debugging time.

Software by J. van de Kamer

MicroPascal

First Prize, Netherlands

AVAILABLE ON CD-ROM · SOFTWARE · PC SOFTWARE '98-'99

As the author is ready to admit, designing a complete compiler involves a vast amount of complex work. Mr. van de Kamer started off within a Borland Pascal environment, but eventually changed to Delphi 1.0, while the final touches to the compiler were made in Delphi 3.0. After about two years of programming activity (approximately 750 hours) and an impressive 29,731 lines of source code, the compiler was ready in the form as submitted for the Software Design Contest launched in the July/August 1998 issue of *Elektor Electronics*.

Compiling is translating

The function of a compiler may be compared to that of a translator. Commands from a higher programming language are converted (translated) into commands from a lower-level language. During the compiling process, the translator module will typically encounter three types of 'word':

- ➜ reserved words such as the commands Begin and End;
- ➜ words representing a value, for example, '1' or 'Joe';
- ➜ words used as a label.

Comment enclosed in braces {} is ignored during the compile process. The syntax of a source code file is checked using a fixed procedure. The first word that has to be found is Program or Init. If not, an error report is immediately returned. Once the right header is found, the translator will start to look for the next one, in this case, an identifier. All relevant information on the program (name, constants, variables, etc.) is then gathered and stored together with the identifier. The examination of the program continues until an error is encountered, or a full stop (.) is found behind a command.
In the compiler, every command is processed as a procedure. If necessary, such a procedure may call itself (this is called 'nesting').

During the compilation process, the first-time appearance of a new command causes the associated machine code to be generated. Because the compiler has a flexible structure, the commands to be generated are stored in a special library file called MCS51.DLL.
Before the actual compiler operation starts, the requisite library has to be loaded into the memory.
Initially the compiler does not know the addresses, interrupts and labels to be used. Consequently, it will first generate so-called relocatable (address-independent) code. This code is stored as a file with the extension 'MPU' (for MicroPascal Unit). This intermediate code must not be changed by the user because the compiler will assume that it has been generated without errors. The file format is universal, allowing the MPU file to be used in combination with other controllers, too.
During the second phase, the file is 'linked', which means that labels, procedures and functions set up in the source code file are coupled to real addresses. The result is a file that may be programmed into an EPROM. For this purpose, MicroPascal supports two file formats: Intel-hex and CPULink.

Memory use

The RAM memory is employed for the storage of variables, procedures, a software ALU (arithmetic Logic Unit), a stack and intermediate results (scratchpad)

Memory is filled from the top to the bottom. For the internal RAM, the top is \$FF, for the external RAM, \$7FFFF (provided 32 Kbytes of external RAM is used). Global variables are held in this external memory. One word, for example, occupies address \$7FFFF for the 'high' byte and \$7FFFE for the 'low' byte. A string made up of 10 bytes is stored in 11 bytes: 10 bytes for the characters and number 11 to indicate the length. The last character is store at location \$7FFFF, the first at \$7FFF6, and the length indicator at \$7FFF5.

Software ALU

To be able to perform arithmetic operations using variables with a size larger than one byte, a software ALU is built into the program. The size of the ALU is geared to the largest value supported by the program. The ALU is divided into two equal sections, lo_ALU and hi_ALU. The ALU is an important piece in the memory. It is used to move variables to and from the stack, and perform arithmetic operations.

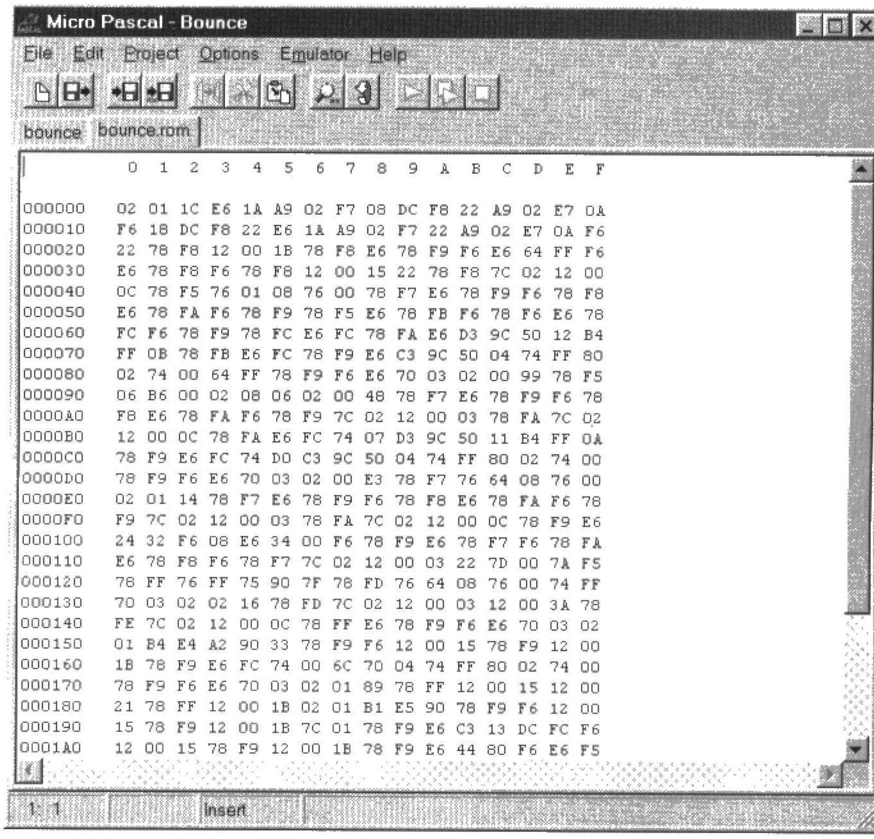

Figure 1. Screendump of MicroPascal in action. The compiler offers a simple way of developing code for microcontrollers from the MCS-51 family. The screens in this article show the source code in a window (introductory illustration), and the final machine code ready for programming into a PROM or EPROM.

Other points of interest

Once procedures and functions are being used, local variables are created that only exist within the relevant procedure or function. Obviously, the compiler has to reserve space for these intermediate variables. The simplest approach is to define memory space for any procedure which pops up in the program. In practice, this results in a lot of wasted memory space. The present compiler first looks for the procedure or function which may be expected to use up the largest number of variables (in bytes). For this purpose, a special buffer area is made available behind the software ALU. All local variables generated by the program are stored in this area.

The remainder of the RAM memory is available as stack space. MicroPascal works 'top down', starting at the highest memory location (\$FF). This system had to be adopted because the controller uses memory locations from \$00 upwards for its internal registers. The processor's own stack is then located immediately above these registers. Both blocks are therefore allowed to grow towards each other as the program is being executed, and no conflict will occur as long as sufficient memory space remains available. If you run low on available memory, simply reduce the number of variables and/or procedures being called.

When calling a procedure it is also possible to convey parameters or variables. If variables are marked with 'VAR' they may be adapted within the procedure called.

To be able to use interrupts, special provisions have to be made in the code. This is necessary because an interrupt may occur at any moment. The interrupt procedure ensures that all data of local variables, as well as ALU data, are safely stored before an interrupt procedure is started. The internal registers are also kept in a safe place. At the end of the interrupt, all relevant information is retrieved and restored to its original state.

Interrupts may be used to adapt globally defined variables. We should hasten to add, however, that variables larger than one byte can not be

Variables and units

Type	value	minimum	maximum
Byte	numerical	0	255
Word	numerical	0	65535
ShortInt	numerical	-128	127
Integer	numerical	-32768	327767
Boolean	numerical	False	True
Char	character	1 character	1 character
String	character	0 characters	size dependent

For a string, the size depends on allocated memory space.
When no length is specifed, the length is limited to 255 characters.

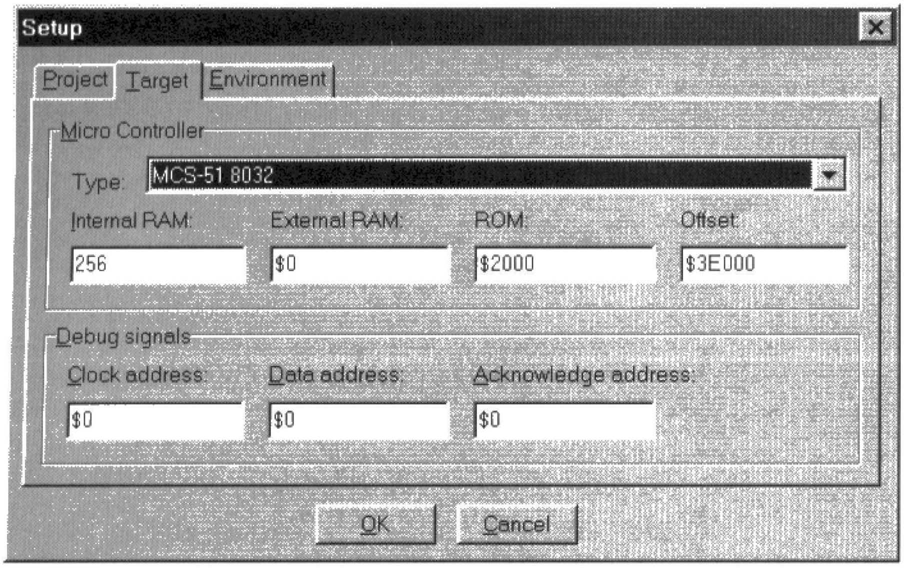

Figure 2. A special configuratuon window allows the characteristics of the MCS-51 system ('terget system') of be set up.

processed. Larger variables are modified with the aid of several instructions having a width of one byte. To communicate with the main program, it is therefore recommended to use variables with a width of one byte.

Debugging

Eliminating errors in software is almost invariably a tedious and time-consuming activity. MicroPascal has a number of extra functions available to simply the debugging process. Additional hardware has been designed in the form of a ROM emulator (size 256 Kbytes). The circuit diagram and PCB artwork for this design may be found on the CD-ROM which contains a number of prize-winning entries from the 1998 Software Design Competition. This CD-ROM will be published early January 1999. The relevant file is called ROM emulator.DOC.

During the linking of a program, each debugging location has its own identification (a value between 0 and 255). This value is saved by the compiler, together with the location of the debugging point (file name and line number). The debugging procedure is implemented in the software by calling a function from the library that first sends the identification, and then the contents of the local and global memory. MicroPascal 'knows' which variables are visible at the debugging point marked by the identification, and displays the received value plus associated variables.

This approach requires three I/O pins of the MCS-51 to be given a specific function. Two outputs, one carrying the clock signal, the TxD line, plus one input employed for handshaking. A simple handshaking protocol is employed. The controller pulls bit 0 at the data output logic low, and places a low level on the clock line. MicroPascal reads the level and pulls the acknowledge line logic low. Next, the controller pulls the clock signal high gain, whereupon MicroPascal does the same with the acknowledge signal. The first bit is then transmitted. This procedure is completed for all bits that have to be sent, except the last one. With this bit, MicroPascal no longer supplies an acknowledge signal, causing the microcontroller to enter an infinite loop. During this period, the results may be viewed and analysed on the PC display. Once all relevant information is known, you only have to actuate the menu option 'Continue' to transmit one acknowledge signal and so get the microcontroller out of its infinite loop. The program is then continues as before.

The primitive handshake was chosen to make sure reliable communication is available under all circumstances. However, the price of three controller I/O pins may be too high in some cases, so that the function is optional.

System requirements

MicroPascal runs under Windows 95 and requires about 10 Mbytes of hard disk space. If the optional ROM emulator is employed, then you also need a free bidirectional printer port.

MicroPascal was developed for MCS-51 microcontrollers and comes with a library for these processors only. Users requiring support for other microcontrollers will have to develop their own libraries.

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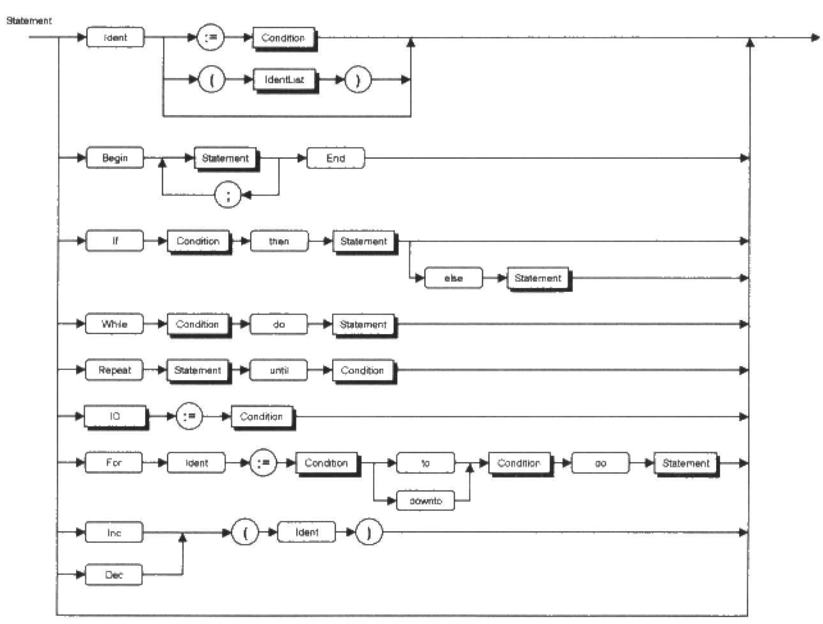


Figure 3. This flow diagram shows the ingenious methods used by the compiler to determine what is meant by a statement in the source code.

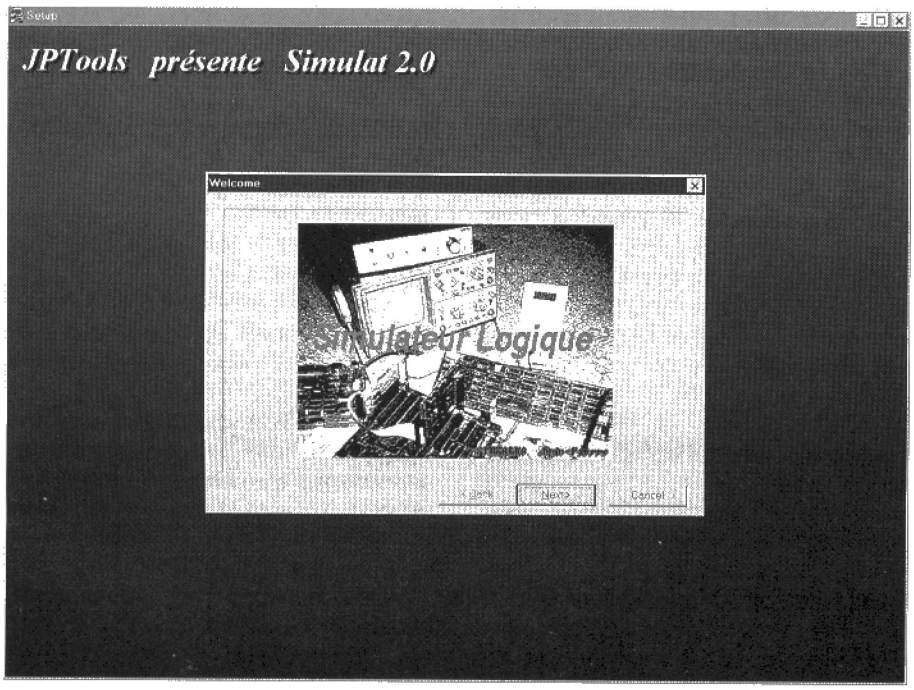
New software to simulate logic circuits seems to hit the streets every month, and most of you will be aware that logic simulation on a PC is a good alternative to wiring up prototypes of digital circuits.

By J.P. Strzalka

SOFTWARE AVAILABLE ON CD-ROM · PC SOFTWARE '98-'99

Logic Simulator 2.0

First prize, France



The logic simulation program 'Simulat 2.0' was awarded the First National Prize for Competition entries sent to our French editorial department. The program is aimed at students, teachers and hobbyists wishing to widen their knowledge of sequential and combinatory logic circuit design.
Simulat 2.0 allows you to draw schematics of logic circuits in a window displayed on your PC monitor. Once you think the schematic is complete, you launch a simulation run using virtual switches, displays or other indicators and devices to control and visualize the way the logic circuit operates (or not!). Simulat 2.0 is capable of handling four schematics at a time.

Program installation
The program is easy to install under the Windows 95 operating system.
Select 'Run' from the Start menu, type 'X:\setup', and then press the Return key, where 'X:' is the letter of the drive station that has the 'setup' file. Alternatively, use the 'Browse' option to get assistance from Windows 95 in looking for the setup program. If you use the Elektor CD-ROM which contains the present project, navigate to the subdirectory /F/01 where you will find setup.exe.
The installation program builds a group of three programs. The group is called 'Simulat', and it will contain three icons. The first icon in the group allows you to actually launch Simulat. To do so, double-click on this icon with the left-hand mouse button. In this way you start the simulator program.

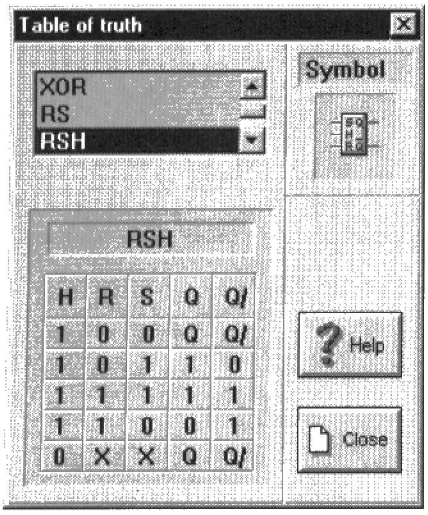
Schematic capture

The program enables you to create circuit diagrams. For this function it offers a number of tools that allow users to include elementary logic elements like gates, flip-flops, adders, multiplexers, demultiplexers, timers or counters in your schematic. A rather complex example of such a circuit is shown by the screendump in **Figure 1**. This is actually a counter circuit.

Simulation program

The 'pencil' tool allows you to connect logic gates. Only right angles are possible for the 'wires'. To use the pencil, pick it from the Tools bar, and left-click on an input or output of a logic operator. Next, move the mouse to the operator you want to connect up, and then release the mouse button.
The 'Copy' utility of Simulat also supports the use of the Clipboard to cut, copy, delete and paste elements in your circuit diagram.
Simulat has deletion utilities: for logic operators, connections and junctions. To delete an object, select the corresponding utility from the Tool bar.

The schematic may be spiced up a bit by text with or without a frame. It is possible to choose fonts, colours and character sizes, as well as text orientation (vertical or horizontal). The user may choose the frame colour, shade

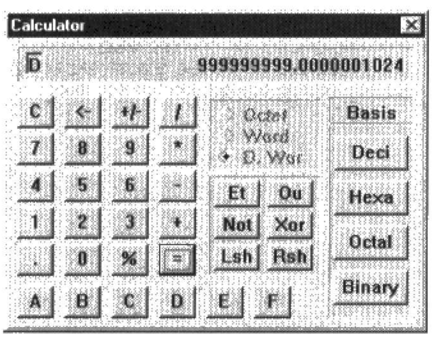


and the frame type. Frame size is automatically adjusted to the amount of text and character height selected by the user.

It is possible to write up some comment with each schematic. The length of the comment text is limited to 50 characters.

Tools

The panoply of utilities found in the working subdirectory is complemented by a powerful 'special logic' calculator which is capable of performing special functions like number conversions and shift-right /shift-left opera-



tions. Using binary number notation, the range of operands is adjustable from eight bits to double 32-bit words. In addition, a truth table is available to help you remember the function of the main logic operators. This useful little tool pops up on the screen if you select the corresponding command. A simple mouse click on one of the logic operator types in the scroll list instantly displays the associated truth table and the corresponding logic symbol.

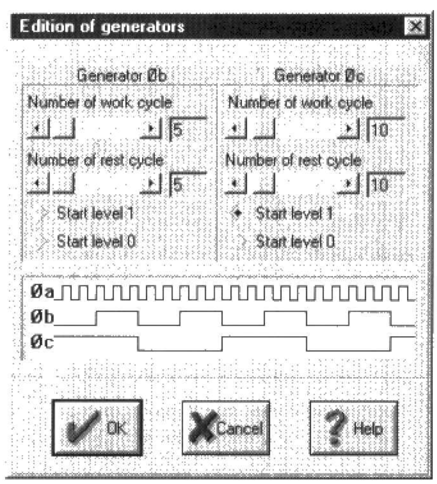
Circuit simulation

Having drawn and saved your schematic, you are ready to launch the circuit simulator. The program will test all connections and display its findings as the test progresses. Any error encountered in this process, is made known to you by means of dialogue boxes. If Simulat does not encounter errors, it is possible to operate the virtual switches, indicator lamps, displays and thumbwheel switches, and so set up and manipulate various conditions to which the virtual logic circuit responds.

The links in the circuit diagram are shown in different colours depending on their logic level. You can read the logic level of an operator by left-clicking on the operator input or output. The cursor will then change to a symbol indicating 'zero' or 'one'.

Simulat 2.0 also comes with a logic oscilloscope capable of displaying up to five signals taken from points you indicate in the circuit diagram. The oscilloscope is 'triggered' by either a rising or a falling pulse edge detected on one of the five input channels. If the oscilloscope trace is not stable, you may insert a trigger delay to keep this virtual instrument synchronized.

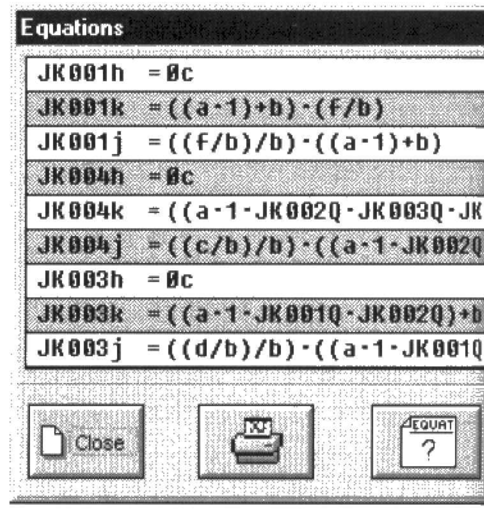
Oscilloscope traces may be copied onto the Clipboard, or saved in a file. Furthermore, scope traces may be sent to the printer to produce hard copy, at a scaling factor you select. Alternatively, Simulat can compute the scale value needed to adapt the size of the drawing to that of the paper in the printer.



Logic equations

Simulat allows you to determine logic equations based on a schematic.

The calculation box identified as 'Equations' allows you to print equations that belong with a circuit diagram, using a number of options (line spacing, separation, page number, etc.). Equations may be saved on the Clipboard or in a file on your disk. It is also possible to compute a partial equation. To do so, you click on the corresponding button shown by the dialogue box. Simulat then temporarily closes the box to enable you to click on the desired logic gate. Once that is



done, the dialogue box pops up again on the screen, showing the logic equation against a red background.

Library

Circuit elements may be saved in order to build a library of basic building blocks.

To do so, you choose the option 'Copy' and then limit the selection to the desired elements by means of a dashed box. Next, you actuate the command 'save model to disk' which may be found in the menu called 'Library'.

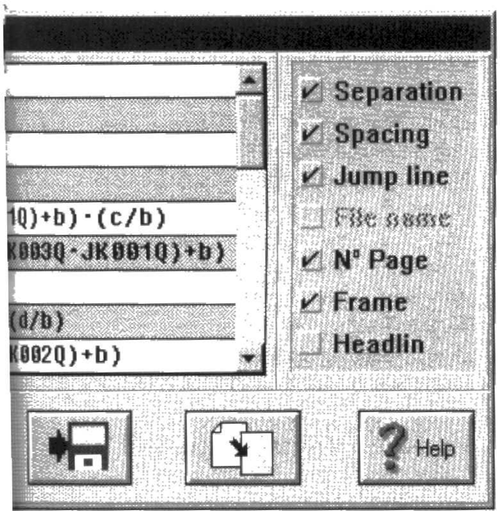
Finally, you may select the command 'Load model from memory'. This causes a certain element to be retrieved from the library and placed at the desired location in the current window.

Utilities & button palettes

The palettes (bars) containing utilities and buttons allow you to change the appearance of the program on the PC screen. Modifying the utilities palette allows you to increase the actually visible area in the window containing the schematic you are working on. In this way, you will be able to see more of your schematic. These palettes may be moved around to any location you want on the screen. Furthermore, the palettes and toolbars may be 'hidden' to create even more space on the screen.

Printing

Simulat 2.0 can provide a Print Preview. This dialogue box allows you to select the printable area, the scale, page margins, contents of the ID box, and other printer configurations,



before the print job is started.
The buttons in the dialogue box are 'repeat' types, allowing the relevant command to be issued again by keeping the cursor on the button representing the desired command.
Compatibility is assured with any printer already functioning in graphics mode, and driven by other applications running under Windows.
To print an ID box with the schematic, click on the button 'Cartouche'. A dialogue box pops up which allows you to define the text fields which are to appear in the ID box.
Paper margins may be set in the dialogue box 'Page Setup' ('Mise en Page'). In the title bar the program display the paper dimensions and the printable area. These two values will of course depend on the printer you have connected up to your PC.

Help system

A powerful, context-sensitive help system is available.
To get help, you click on the 'Contextual Help' symbol in the button bar. Next, you click your way through the Help menu to get to the item you need help on.

File management

The file management system allows you to stay organized as far as your schematics are concerned.
The system offers you a number of possibilities for copying, moving, loading, opening and deleting your schematics. It also supports displaying file properties of disk drives, and free space on the hard disk.

Miscellaneous matters

Because Simulat 2.0 runs under the Windows 95 operating system, you are able to copy complete screens into the Clipboard, and from there move them to other applications like MS Write, etc., in order to create documents (useful for educational/didactic purposes).
Simulat 2.0 supports the Multiple Document (MD) system. The program allows you to work on four circuit diagrams simultaneously. The names of the schematics are displayed in the 'Window' menu ('Fenetre'). You can change between circuit diagrams in three ways:
- by left-clicking anywhere in the window of the schematic to be activated;
- by clicking on the name of the schematic as listed in the 'Window' menu;
- by selecting the 'Next' option from the System menu in a window.

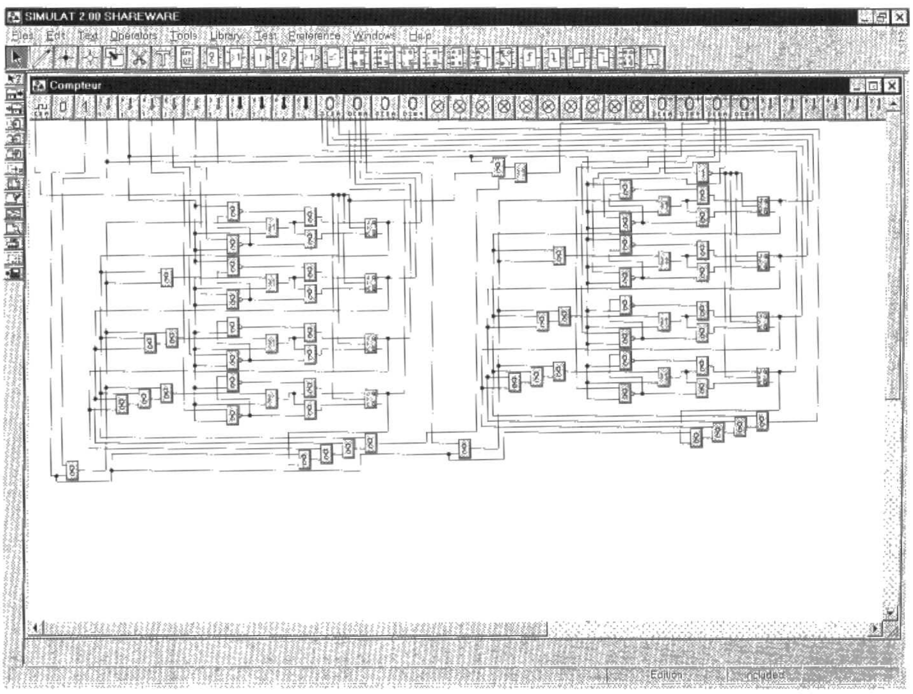
Simulat 2.0 also supports the OLE 2.0 system. The linking and embedding functions allow Simulat 2.0 to accept different data types and objects produced with other programs. The main difference between *linking* an object and *embedding* it concerns the way in which data is stored: embedded objects form part of a schematic (i.e., they are integrated into the file), while linked objects remain stored in the original (source) file. The schematic then only keeps information relating to the location of the object in the source file.
Circuit diagram files may be selected and moved into the simulation window. Using the file management system you may pick one or more schematics and drop them in the simulation window. Once the cursor is on the program window, release the mouse button, and the selected files are loaded into the simulator. Note that Simulat 2.0 can only handle four schematics at a time.

System requirements

You will need to have Windows 95 installed (or a later version). The PC should have a 386 processor or better, 4 Mbytes of RAM, a VGA card and a mouse. Simulat 2.0 requires about 6 Mbytes of free space on your hard disk.

Note: The version described here supports a maximum of 100 components. The author can supply a larger version.

(992014-1)



Temperature Recorder employs a DS1620 transducer and an AT89C1051 RISC microcontroller to record and storing temperature values. The microcontroller effectively connects the transducer to the serial port (RS-232) on your PC.

By John Th. Kokkori

temperature recorder

First Prize, UK national entries

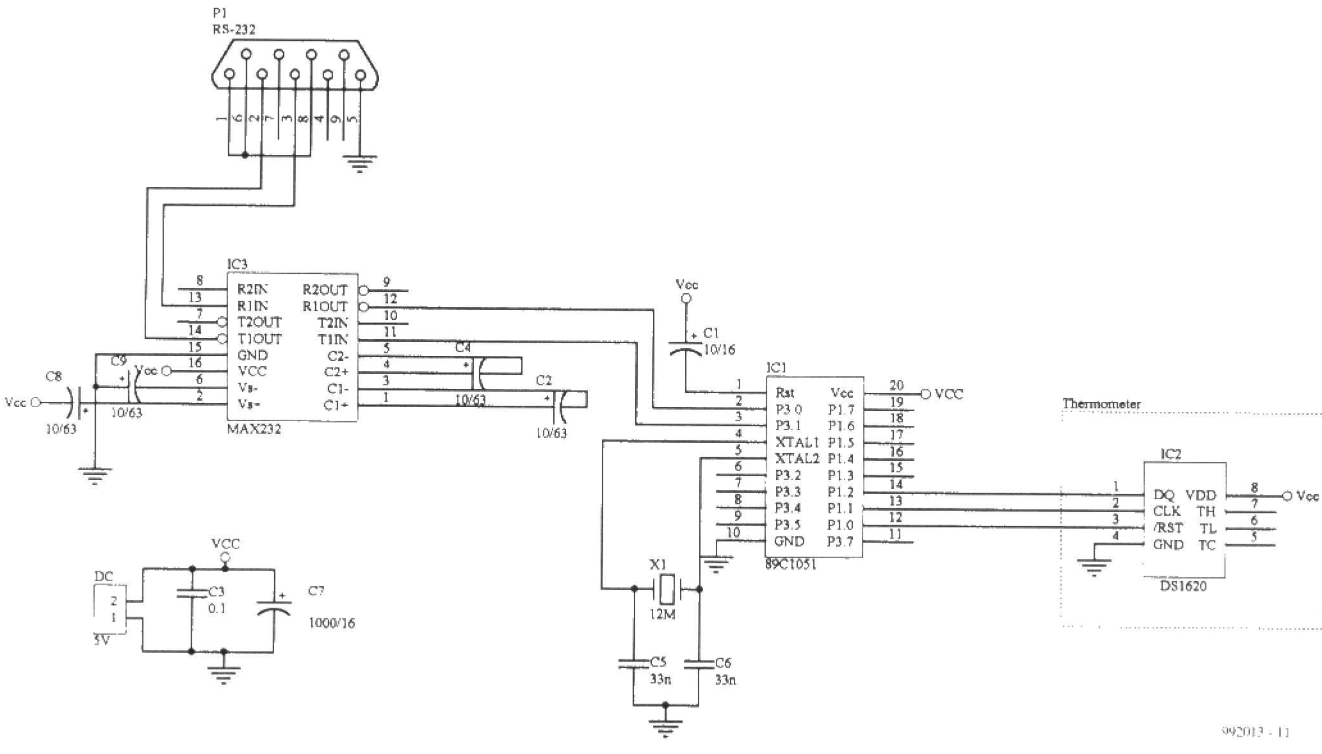


Figure 1. Circuit diagram of the intelligent interface and its connection to the PC's serial port.

Thanks to an Atmel 89C1051 controller in the purpose-designed interface shown in **Figure 1**, the system is capable of performing temperature readings and storing measured values while the PC is off. Also, the actual thermometer may be located at quite some distance from the host PC. The PC, when switched on, may request the temperature readings from the interface, and use them to display a temperature graph. The interface is built on a small printed circuit board as shown in **Figure 2**.

Program description

Temperature Recorder is a Win95/98/NT application written in Visual Basic 5. This program allows you to select the COM Port to which the thermometer is connected, as well as define the value of parameter 'RATE' which is the interval between two temperature readings. This is defined by the equation

TIME = (RATE + 1)*30 [seconds]

For example, if RATE is 0, the sampling interval is 30 seconds, and if RATE is 19 the interval is 10 minutes.

Using 'Read Buffer Data' you can prompt the microcontroller to transmit its buffer contents to the PC. Before you start the transfer you should enter, in the 'Filename' field, the name of the file which is to contain the temperature readings (see **Figure 3**). Alternatively, or you can choose an existing file by clicking on 'File' and then 'Select File ...'. Having selected the file you may press the 'Start' button, whereupon the discrete temperature values will be

written into the file. You will also see the time, date and the value of the last temperature reading. If you press the 'Show Graph' button the system presents a graphic display of the measurement results.

Installing the program

To install the program you simply run the 'Setup' file.

If you have a different version of Visual Basic installed on your PC you may have a problem with the installation. In that case, do not stop the installation. Once Setup has finished, copy all files, **except** 'Vbctrls.reg' from the disk 'Temp_Rec / PATCH', to the Windows system directory, then run the file 'Vbctrls.reg' from the 'Temp_Rec / PATCH' disk. This will update the relevant files in the system directory, and the program should then work.

All files available!

The software as supplied for the *Elektor Electronics Software Design Contest* includes all the source codes for the Temp_Rec Program (in V.Basic 5), the asm, hex files for the microcontroller and the PCB artwork and schematic files (Protel files and image files) for the thermometer.

All software components as supplied by the author may be found on a CD-ROM containing winning entries from the 1998 Software Design Contest. This CD-ROM will be available early January 1999.

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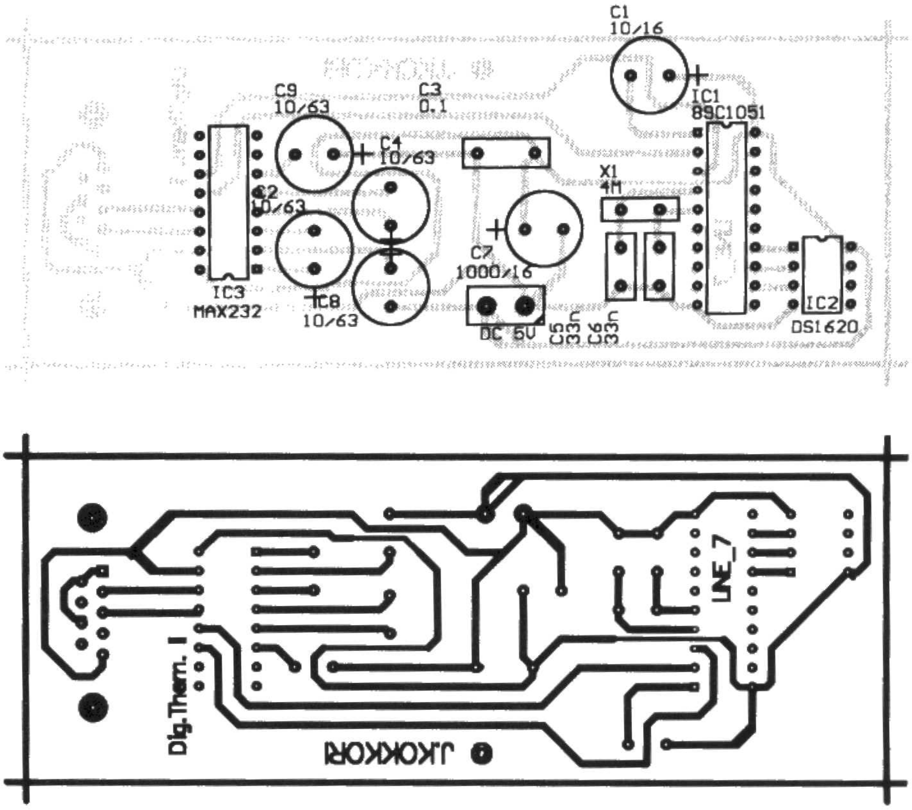


Figure 2. PCB artwork as supplied by the author.

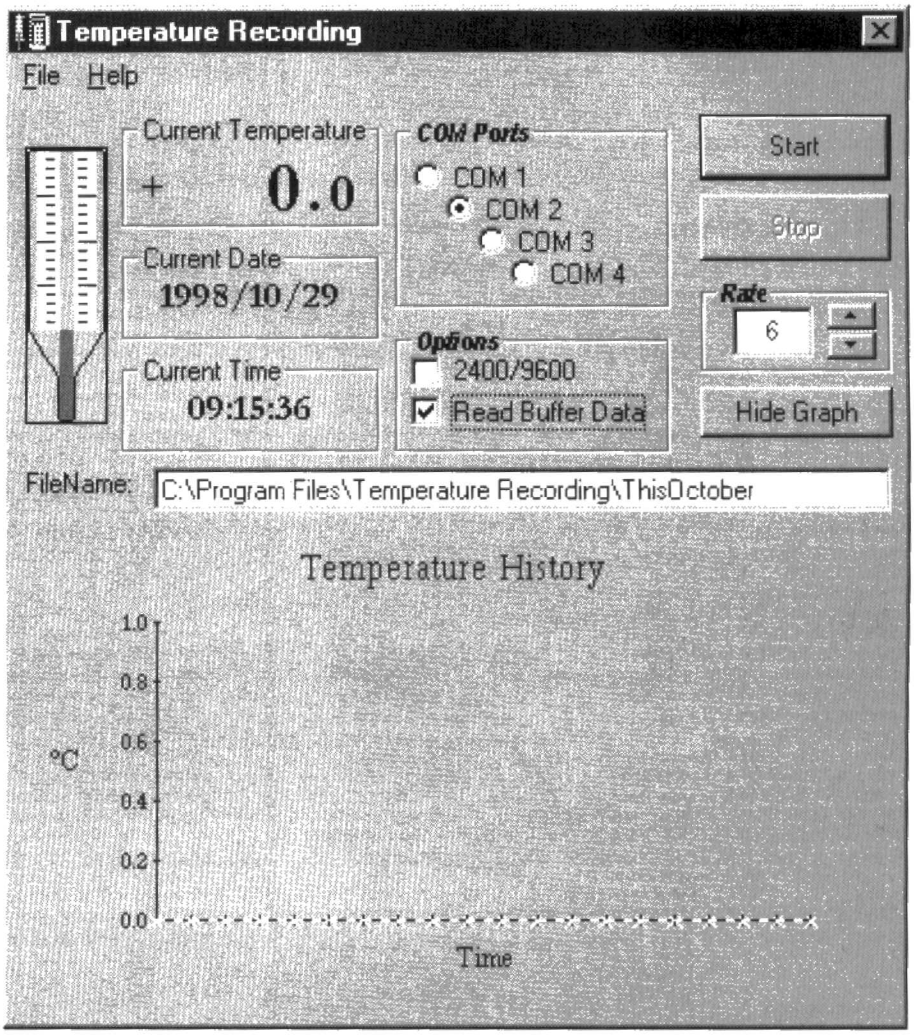
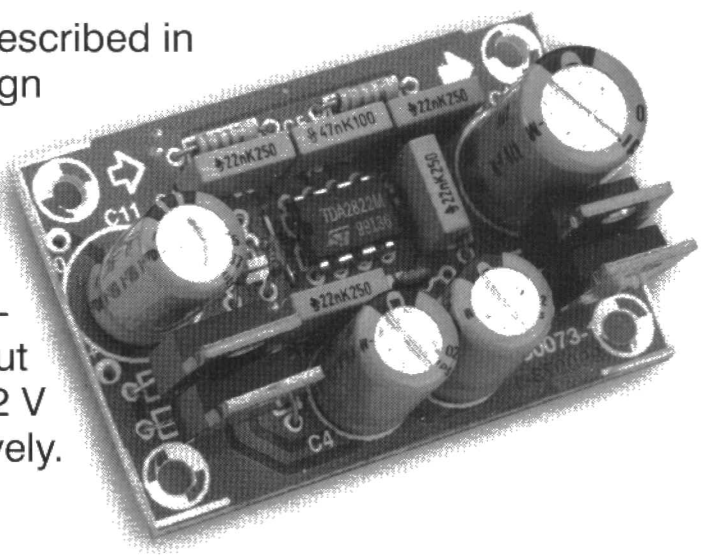


Figure 3. Screendump showing Temperature Recorder in action.

DC-DC step-up converter

no-iron converter for mobile charging of low-power battery packs

The voltage step-up converter described in this article is a transformerless design based on just one integrated circuit and a handful of passive parts. Efficiency is excellent given the simplicity of the circuit, which requires no modifications for any input voltage between 6 V and 12 V, for output voltages of about 10 V and 22 V respectively.



One of the most frequently used applications of voltage step-up converters is that of a battery charger using the 12-V vehicle battery as its input power source. After all, to charge a battery, you need a voltage which is always greater than the maximum voltage supplied by the battery when fully charged. So, charging a 12-V NiCd battery pack as used in, say, a portable mobile radio or a laptop computer from the car battery calls for a circuit that increases ('steps up') the 12-V input voltage to, say, 20 V or so which may be applied to the charger circuit.

Not so long ago, it was practically impossible to design DC-DC step-up converters without recourse to special transformer techniques using the inverter principle: use the input voltage to power an oscillator which drives a step-up transformer; next, rectify the high voltage at the secondary. Such circuits are typically bulky and not terribly efficient, although there are noticeable exceptions.

Today, most step-up converters are tailor-made switch-mode power supplies (SMPSUs) based on purpose-designed ICs. The design presented here is an exception in that it employs a low-cost audio power amplifier IC, the TDA2822M.

STEP UP THE VOLUME

Looking at the circuit diagram in **Figure 1** you will not fail to note the simplicity of the circuit. Basically, the inputs and outputs of the two amplifiers in the TDA2822M are cross-coupled by capacitors C2 and C7 to cause a (controlled) amount of oscillation. In fact, you are looking at a double AMV (astable multivibrator) acting as a push-pull oscillator/charge pump driving a classic diode-based voltage multiplier.

Design by W. Zeiller

Simple as it may be, the circuit acts as a reasonably efficient voltage doubler (theoretically, that is).

Through their output capacitors (C4 and C9) and associated diode pairs (D1-D2 and D3-D4), amplifiers IC1a and IC1b alternately contribute to the energy (charge) built up in output capacitor C10. This energy is available for use by the load connected to the converter output terminals.

Theoretically, the input voltage is doubled, but there are derating factors. Firstly, the output transistors of the TDA2822M are not ideal devices and cause a small voltage loss. Add to that the voltage drop across the diodes and you will appreciate that an input voltage of 12 V produces an output voltage of just 22 V instead of the theoretically expected 24 V. Unfortunately, the output voltage drops a little more when the converter is actually loaded, but that will not be a problem in most battery chargers thanks to their internal regulator circuits (for constant current or constant voltage).

The oscillator operates at a frequency of about 2 kHz. This value depends to some extent on the actual supply voltage and the load current. The Boucherot networks at the amplifier outputs, R3-C3 and R4-C8, may come as a surprise here because they typically occur in audio amplifiers were they serve to 'straighten' loudspeaker impedances. Here, the main purpose of the networks is to stabilize the converter when the diodes are switching.

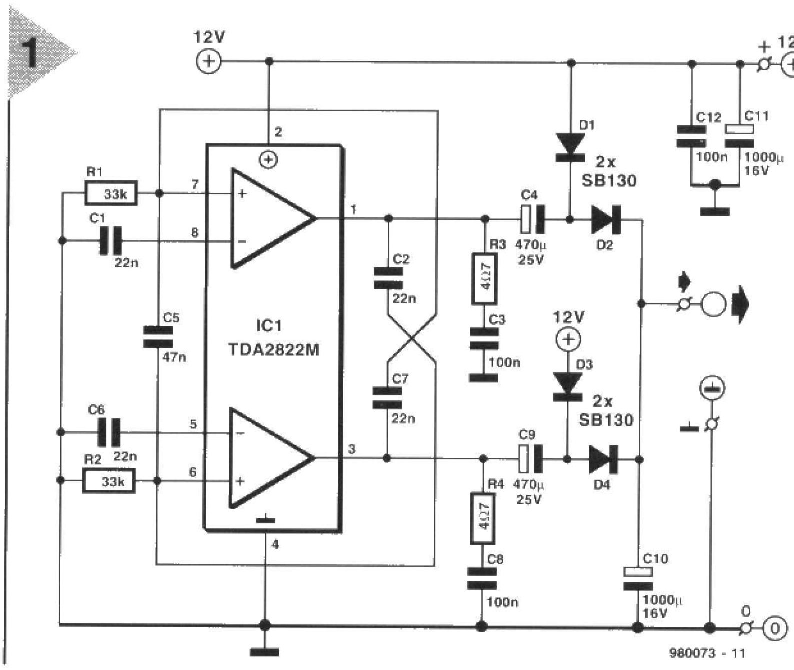


Figure 1. This transformerless DC-DC step-up converter is based on a stereo power amplifier IC, the TDA2822M. Here, the two opamps are wired as a cross-coupled double AMV driving a traditional diode-capacitor voltage doubler. Switching frequency is about 2 kHz.

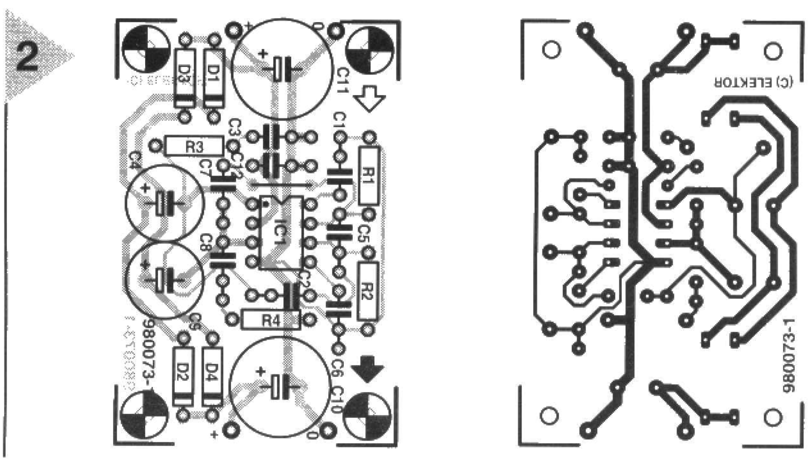


Figure 2. Copper track layout and component overlay of the printed circuit board designed for the converter (board not available ready-made).

Construction

The circuit is best built on a printed circuit board of which the copper track layout and component-mounting plan are given in **Figure 2**. Construction should be a piece of cake, the board being single-sided, and only common-or-garden components are used. Do make sure, however, that the following parts are mounted the right way around on the board:

- electrolytic capacitors C4, C9, C10, C11;
- diodes D1, D2, D3 and D4;
- integrated circuit IC1.

Having finished the solder work you should subject the board to a thorough visual inspection, and correct any obvious errors before you power up for the first time.

If difficult to obtain locally, the type SB130 diodes may be replaced by almost any other medium-power Schottky diode capable of passing at least 1 A. In the prototype, the well-known BYW29 was tried and found to give good results, too.

Finally, be sure to use the TDA2822M only. Because of its 8-pin DIL enclosure, it is the only version that can be used on this printed circuit board.

Performance

The maximum continuous output current that can be supplied will be about 300 mA. The no-load current consumption of the converter is between 6 and 8 mA. A prototype of the converter was put through its paces in our design laboratory, with the following results:

U_{in}	I_{in}	U_{out}	I_{out}	*Efficiency*
6 V	0.22 A	10 V	0.1 A	80%
12 V	0.44 A	21.3 V	0.21A	85%

Not spectacular, but not bad either for such a simple design! (980073-1)

COMPONENTS LIST

Resistors:
R1,R2 = 22kΩ
R3,R4 = 4Ω7

Capacitors:
C1,C2,C7,C7 = 22nF
C3,C8,C12 = 100nF
C4,C9 = 470µF 25V radial
C5 = 47nF
C10 = 470µF 40V radial
C11 = 1000µF 16V radial

Semiconductors:
D1-D4 = SB130, BYR745 or BYW29
IC1 = TDA2822M (SGS Thomson)

RadioText

Radio Teletext now also in Europe

Some European broadcasting organizations have introduced, or are introducing, an improved version of the Radio Teletext service inaugurated in the United Kingdom by a number of commercial radio stations in the late 1980s. Like the UK Radio teletext service, RadioText is separate from, but in addition to, RDS (Radio Data Services). The RadioText data are carried on a 76 kHz sub-carrier (UK Radio teletext: 69 kHz), FM (FSK) modulated at 16 Kbit/s (UK: 5 Kbit/s) with the FM carrier deviated by ±5.5 kHz (UK: ±7.5 kHz). Sony has designed a receiver, Textman, specially for the reception of the RadioText service.

By our Editorial Staff

INTRODUCTION

The Radio Data System (RDS) is a European system for broadcasting digital data on VHF/FM transmitters. The spectrum of the VHF/FM signal is shown in **Figure 1**. Receivers equip-ped with RDS decoders decode the digital data which may include automatic tuning, station identification, service identification, accurate time, a radio paging service, and much other information,.

The RDS specification was adopted by the European Broadcasting Union (EBU) in 1984 and is now implemented on most European VHF/FM broadcast transmitters.

Information at a data rate of 1.1875 Kbit/s in groups of 104 bits is superimposed on to a 57 kHz sub-carrier locked to the 19 kHz stereo pilot tone. The final multiplex (L+R signal, 19 kHz pilot tone, L–R signal on a suppressed 38 kHz sub-carrier, and the RDS signal) frequency modulates the main carrier.

Each of the groups of 104 bits into which the bit stream is divided is subdivided into four blocks of 26 bits. Each block contains a 16-bit information word and a 10-bit checkword for,

among others, error detection and a degree of error correction.

DATA RADIO CHANNEL

In the early 1990s, the American company Digital DJ introduced a special data service, called Data Radio Channel – DARC – for VHF/FM broadcasts. The system was developed by the NHK Science & Research Laboratories in Tokyo. Note that this is not based on the American Subsidiary Communications Authorization (SCA) system that dates from the early 1980s and on which the UK Radio Teletext service is based. The system has been accepted by the International Telecommunications Union (ITU) as a standard.

It is interesting to note that the DARC occupies a band of 16 Kbit/s, which is more than ten times as wide as the RDS channel (1.1875 Kbit/s).

The DARC is broadcast in the USA to support normal radio programmes with Programme Associate Data (PAD). This service enables programme information, such as names of performers, cast lists, station identification, and so on, to be displayed on the liquid-crystal display (LCD) of a suitable receiver or, by means of appropriate software, on the monitor of a computer.

DARC TECHNOLOGY.

In the DARC, data are carried on a high-speed sub-carrier of 76 kHz—see Figure 1.

Information at a data rate of 16 Kbit/s is superimposed on to the 76 kHz sub-carrier which, being the third harmonic of the 19 kHz stereo pilot tone, is readily locked to this tone. The final multiplex, including the L+R signal, the 19 kHz pilot tone, the L–R stereo difference signal on a suppressed 38 kHz sub-carrier, and the DARC signal, frequency modulates the main carrier at ±5.5 kHz.

The modulation factor is 0.1. The level of the high-speed sub-carrier may be increased to –20 dB to reduce any crosstalk from the main carrier.

After error corrections and other necessary manipulations, the bandwidth of 16 Kbit/s is reduced to 8 Kbit/s, via which about 1000 alphanumeric characters per second can be transmitted.

The data superimposed on to the high-speed sub-carrier is generated via a computer running Workbench of Digital DJ. After encoding, the signal is sent in accordance with the USEP emulation protocol to the main transmitters via a microwave network and a DARC encoder—see **Figure 3**.

1

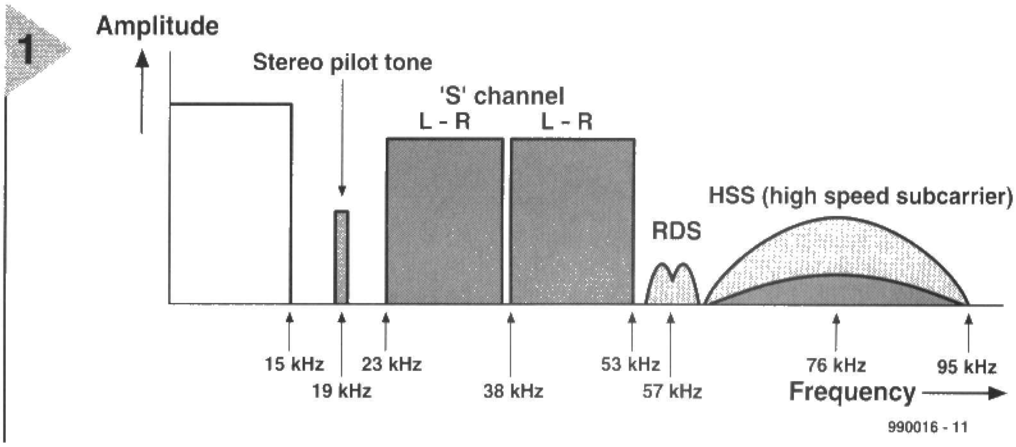


Figure 1. Spectrum of a VHF/FM signal that contains the normal stereo audio signals, the RDS data channel, and the Data Radio Channel—DARC.

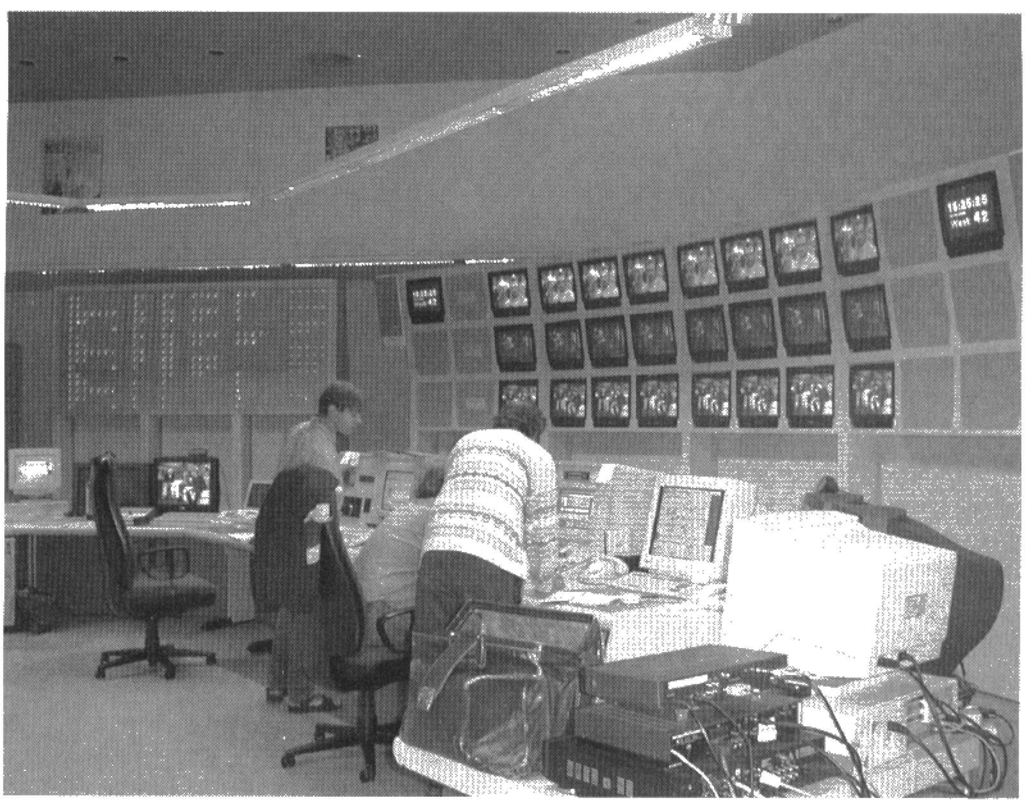
RADIOTEXT

Most data on the RadioText service are derived from the local television's teletext service but, although this latter service contains thousands of pages, RadioText will be limited to a few hundred. These pages will be transmitted again and again, repeated every few minutes. The Textman or other suitable receiver stores all the information before it can be seen on the display. This means that the waiting times when leafing through pages on TV Teletext are not encountered with RadioText. Because of the error correction, pages cannot be mutilated: a page is received either in good order or not at all.

The resolution of the LCD on the Textman receiver is seven lines each of not more than 21 alphanumeric characters. Graphics, such as logos, may also be displayed. All information is, of course, in black and white.

In Europe, as in the UK and USA, RadioText is primarily of interest to commercial broadcasters, since the service is free (so far) to the recipient and must, therefore, be paid for by adver-

Figure 2. Typical broadcasting control room where data can be prepared for dissemination via the VHF/FM radio network.



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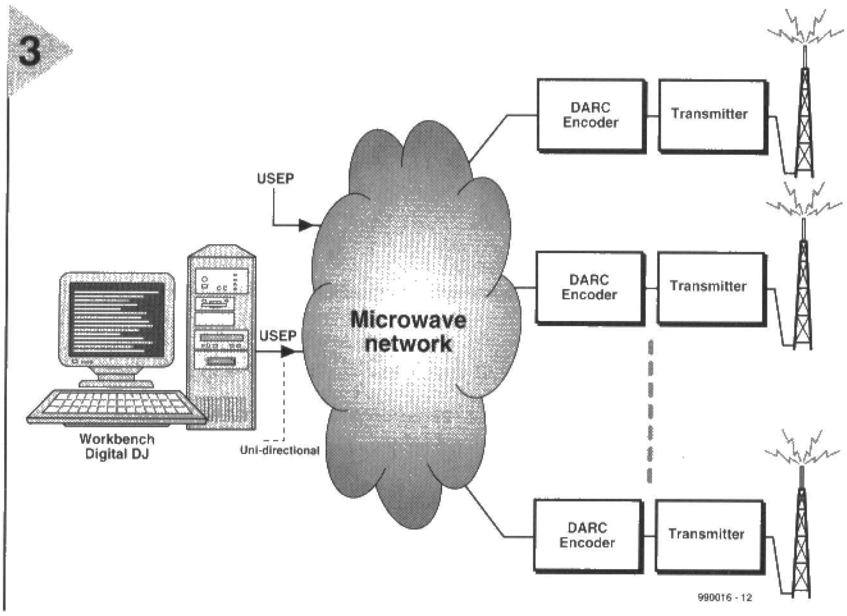


Figure 3. Diagram of a broadcasting network that transmits Radio-Text data.

tisers. However, the Textman is already provided with facilities that enable services to be paid for before they can be displayed.

The RadioText service may eventually also be used for radio paging, but at present there are no definite plans for this. Nevertheless, each Textman receiver is already provided with a unique code, which can be accessed via the menus of the receiver.

TEXTMAN SRF-DR2000

The only receiver currently commercially available for the reception of RadioText is the Sony Type SRF-DR2000 Textman. The ICs used in the receiver are Sony designs, which are not (yet) available to other OEDs. When they become, the RadioText facility may also be built into mains-operated tuners and car radios.

The Sony receiver looks like the familar Walkman™ with controls for five preset transmitter. It has a black and white display with associated menu controls. Its internal memory enables important messages to be stored for some time.

A drawback of the receiver is that an earpiece has to be used since the lead of this forms the antenna without which, of course, the receiver works badly or not at all.

The receiver may be used all over Europe and, with a suitable configuration menu, in North America.

There is an automatic power-off facility which ensures that the batteries are not exhaused when the user forgets to switch off the receiver.

An FM data control on the front panel enables the FM data decoder to be disabled when no data services are used. If the receiver is used as a standard portable receiver, the data decoder is switched off automatically after twenty minutes.

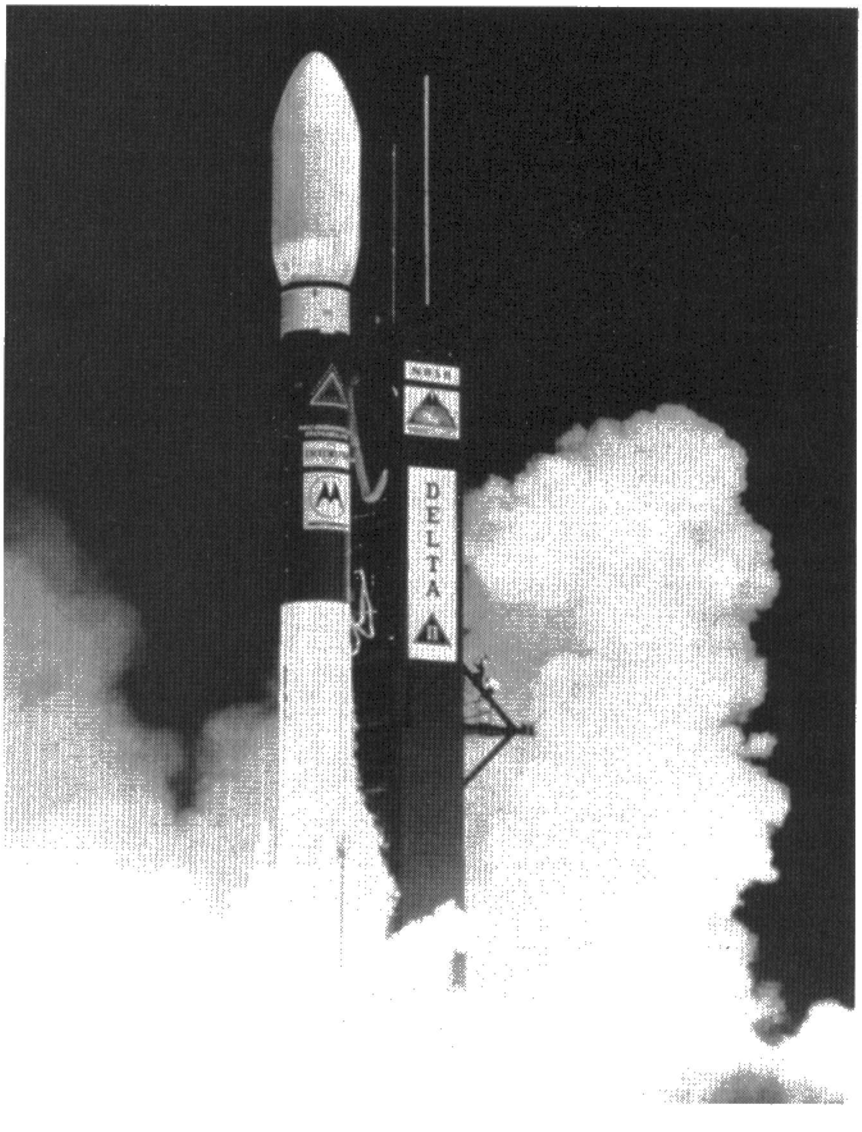
FINALLY

If the RadioText information is disseminated via low-power local transmitter, the system may be used to give drivers parking information in car parks, or draw the attention of customers in a department store to special offers, and so. At music festivals, visitors may be advised via radio of the names of the performers and, indeed, what is being performed. [990016]

Figure 4. The Type SRF-DR2000 Textman receiver from Sony.

The Iridium Network

Mobile telephony via satellite



Proliferation of mobile phones is already a fact, but worldwide mobile telephone communication has become possible only with the advent of the Iridium Network. The network is a joint venture between US organizations Motorola and Lockheed Martin Corporation, and the Russian Krunichev State Research Space Centre. The first satellites were launched towards the end of last year; when fully operational, the network will embrace 66 satellites in various orbits around the earth at a height of some 780 kilometres (470 miles). This fairly low orbit is dictated by the relatively low power of mobile phones.

By our Editorial Staff

INTRODUCTION

Iridum is the first truly worldwide functioning satellite telephone system. The name 'Iridium' was chosen because the original concept of the network envisaged 77 satellites and iridium, a metallic element of the platinum family, is number 77 in the Periodic System. Although the final network will consist of 66 satellites (plus six spare), the name was retained, probably because the element at number 66 of the Periodic System, dysprosium, a member of the rare-earth group, is a rather more difficult name to remember.

Basically, the system works as follows. A call from a mobile phone is transmitted to the nearest Iridium satellite, from where it is relayed to another satellite in the system which is nearest the call's final destination. From this, the signal is beamed down to another cellular phone or a traditional line telephone.

Not many people may have noticed it, but the first Iridium satellite was taken into operational use a couple of months ago. With this, a concept that at its birth 11 years ago was dubbed 'sci-

ence fiction' by many, became reality.

Many aspects of the network are new (at least as far as non-military use is concerned).

- Instead of some large geostationary satellites, it uses a fairly large number of smaller ones in low orbits.
- All satellites are in communication with each other and so form a truly worldwide network.
- Mobile phones and pagers anywhere in the world can be accessed directly by the relevant satellite, which means that the system is independent of terrestrial infrastructures.
- The system is compatible with all current terrestrial mobile telephone networks, such as GSM (Global System for Mobile Communication) in Europe, IS-95 in the USA, PDC in Japan, and others. This means that from now on a GSM user can communicate with an IS-95 user (which until recently was impossible).
- An Iridium subscriber can be contacted from anywhere in the world on just one number – which may be his/her current mobile phone number.

LEO/MEO VS GEO

Until Iridium became operational, civil satellite communications were conducted almost exclusively by geostationary (GEO) satellites about 36 000 km (almost 22 000 miles) above the earth. Exceptions were, for instance, the television satellites in the former Soviet Union which, to cover the extreme north of the country, were in highly elliptical orbit.

The Iridium Network is the first civil communication system that uses satellites in low-earth orbit (LEO) and medium-earth orbit (MEO), which lie between 700 km (425 miles) and 10 000 km (about 6 000 miles).

The difficulty with using high-orbit satellites is not so much the requisite high (transmitter) power or more sensitive receivers in the mobile phones (which would become much larger), but rather the signal delay, particularly in the case of digital equipment. The only satellite telephone service prior to Iridium was via the geostationary Inmarsat satellite which uses equipment the size of a briefcase and requires the antenna to be directed at the satellite. As Inmarsat will continue their GEO service, they have indicated that the user equipment will be drastically reduced in size.

Other planned systems – see overview in Table 1 – will, however, use LEO and MEO satellites.

The LEO satellites in the Iridium Network orbit the earth in about 100 minutes. Motorola's future system, Celestri, is planned to use LEO as well as MEO satellites. This system will provide video, interactive multimedia, and data services.

Another system of the future, Microsoft's Teledesic, is planned to become an Internet satellite network.

A quite different approach is that of Ellipso, which is intended for communications over the northern hemisphere, supplementing terrestrial services. This network will use highly-elliptical orbit (HEO) satellites, the height of whose orbit will vary from 500 km (300 miles) to 8 000 km (almost 5 000 miles).

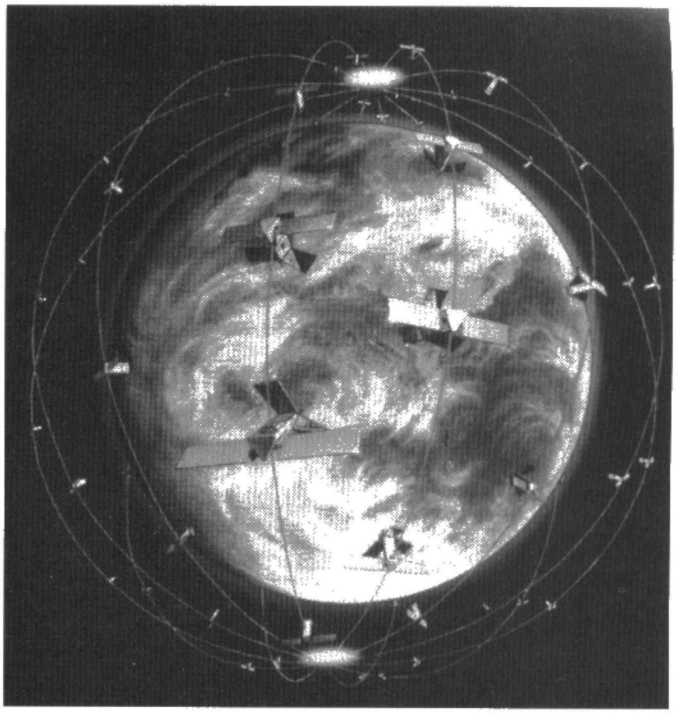


Figure 1. The 66 operational satellites in the Iridium Network use six different orbits to provide worldwide communications.

THE IRIDUM NETWORK

The Iridium system embraces 66 operational and six spare satellites. It is planned to have a life of 5–8 years. To enhance the reliability of the system, a number of additional satellites have been put into orbit, which enable a number of control centres to monitor the movements and working of the operational satellites in their orbits. The main monitor centre in Landsdown, Virginia, USA, is supported by fixed monitor stations in North Canada and Hawaii, and a transportable one in Iceland.

Each satellite is in contact in four directions with other satlelites in the system in the Ka-band (18–30 GHz).

The satellites are linked to the terrestrial networks by twelve gateways (earth stations) on four continents. Three or four 3-metre diameter rotary parabolic antennas track the high-speed (29 000 km/h – 17 500 mph) satellites and transfer voice and data information. Communication between the control satellites and the gateways is in the Ka band (down-link 19.4–19.6 GHz; up-link 29.1–29.3 Ghz).

The gateways pass the information to the relevant terrestrial network (and convert the used protocol if necessary) and also manage and store any information for relay to Iridium pagers. The European gateway is at Fucino in Italy.

Communication between the operational satellites and the providers of the mobile phone and pager services is in the L-band: 1616–1625.5 MHz. The same frequencies are used for the up and down links, which allows the same components to be used for transmitter and receiver.

As an aside, the use of L-band downlink frequencies is likely to cause problems for radio astronomers, since they are very close to one of the spectral lines (1612 MHz – the others are at 1665, 1667, and 1720 MHz)) of the hydroxyl molecule (HO), which is one of the most important frequencies for radio astronomers.

Name of system	Operator	Satellites	Planned for
Inmarsat	Inmarsat	12 GEO	Late 1999
Globalstar	Global Star	64 LEO	Late 1999
ICO	ICO Global Communications	12–15 MEO	2000
Spaceway	Hughes Communications	12–20 GEO	2000
Celestri	Motorola	63 LEO/GEO	2001
Odyssey	TRW/Teleglobe	12 MEO	2001
Skybridge	Alcatel Alsthom	64 LEO	2001
Teledesic	Microsoft	288 LEO	2002
Ellipso	Mobile Communications	17 HEO	2002

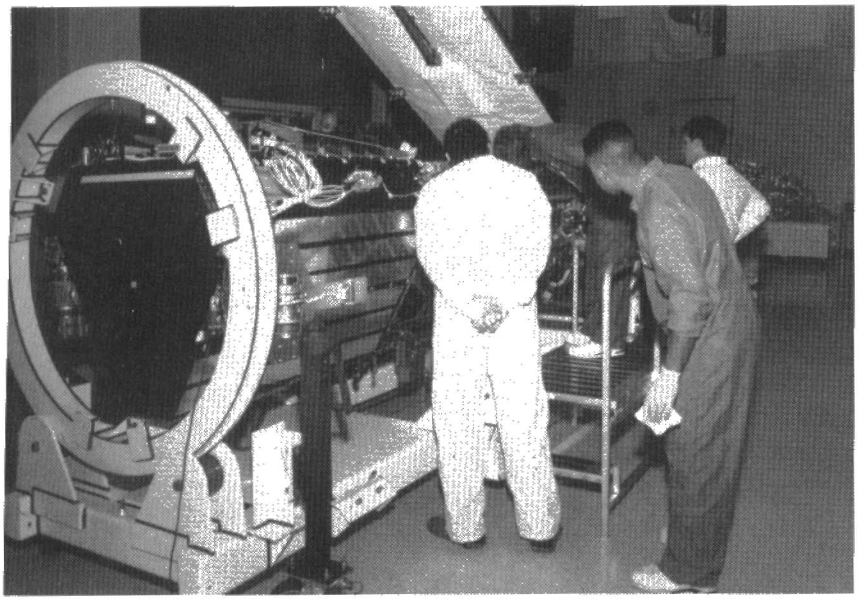


Figure 2. Assembly of the nearly 700 kg weighing satellite at the Motorola-SATCOM plant in Chandler, Arizona. Note the triangular cross-section of the carrier structure which is made of reinforced man-made fibre.

MOBILE PHONES AND PAGERS

The mobile phones and pagers are manufactured by Motorola and Kyocera. The mobile phones are very similar to those used on GSM networks and are able to operate not only with the Iridium standard, but also on a number of other standards, such as GSM and IS-95.

The two designs are quite dissimilar. The Motorola phone is primarily intended for use in the Iridium system, which can be expanded by an optional cassette (which can be slotted into the phone) for use in terrestrial mobile phone services. Each different standard requires a different cassette, for instance, in Europe, a 900 MHz or 1800 MHz GSM model; in the USA, Africa and Russia, an 800 MHz IS-95 version.

The phone weighs about 450 grams. In satellite service, its average transmit power is 645 mW, but there is a link margin of about 15.5 dB. The current price, including one cassette, is about $US3,000.

The Kyocera design is quite different, almost the opposite of the Motorola phone. Its handset, which weighs only 80 grams, is intended primarily for use in terrestrial mobile phone systems. If communication via satellite is required, the handset is inserted into a special 'docking station': the combination weighs 450 grams. When the user travels from an area with a different service standard, a second handset is needed. The docking station and batteries can be used irrespective of which standard prevails.

PAGING VIA IRIDIUM

The Irridium Network is not only the first global mobile telephone service, but it also offers the first paging service that ensures accessibility anywhere in the world without a mobile phone or with the mobile phone switched off. The message sender need not know where the recipient is as this is automatically established by the Iridium system (provided, of course, that the pager is switched on). The Iridium Paging Service allows alphanumeric mes-

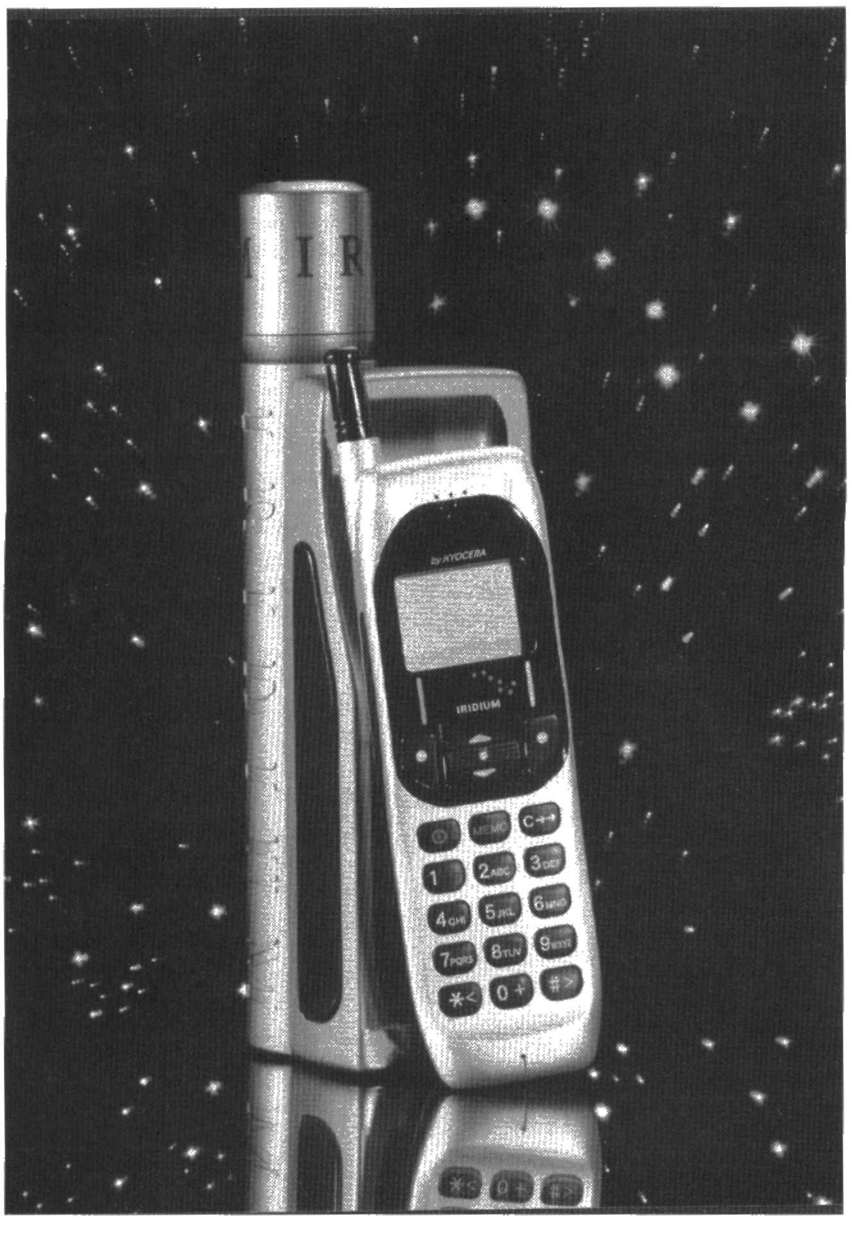


Figure 3. The Kyocera Iridium phone cosists of a handset intended for terrestrial services which is transformed into a satellite mobile phone by inserting it into a 'docking station' with L-band antenna.

sages of up to 200 characters as well as numerical ones of up to 20 ciphers. The pager specifications embrace international graphic characters and LED displays. There is an optional possibility of sending a message to groups of addresses. The batteries last for about 30 days.

OPERATORS AND PROVIDERS

Although the design of the equipment was carried out by Motorola and that of the satellites by Lockheed Martin, the Iridium Service is operated by Iridium LLC. This is an international consortium of communication companies and other industrial organizations, including Motorola, Lockheed Martin, British Aerospace, INMARSAT, and others, which have invested in the development and marketing of the Iridium service.

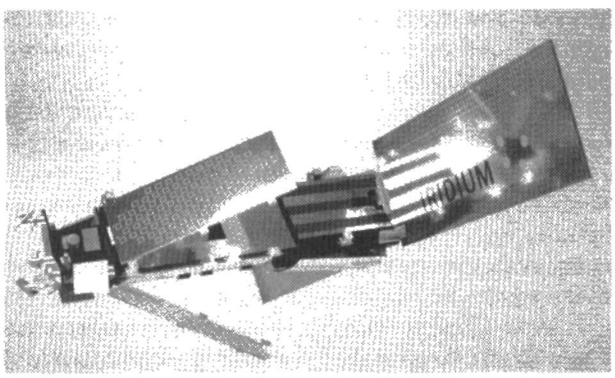
The consortium has representatives in 15 countries all over the world. At the time of writing, it had concluded about 300 agreements with service providers and roaming partners, which together represent more than 100 million customers in 122 countries. Further agreements in more than 100 countries are confidentally expected within the first few months of this year.

Users of current mobile phones can obtain information on the Iridium service, and possibly relevant handsets, from their current provider. Billing for the Iridium service is through these providers. Also, they retain their current mobile phone number. People who do not want to use terrestrial mobile phone services can take out a satellite-only mobile phone contract, and this service issues numbers starting with the international code 8816.

[990003]

Figure 4. Iridium pager and mobile phone from Motorola. The phone has an interchangeable frequency module for a number of mobile phone standards and needs an additional L-band antenna unit for operation in the Iridium Network.

The Iridium Satellites



Each of the 66 operational and fourteen spare and control satellites built so far weighs 689 kilograms (just over 1500 pounds) and is 4.5 metres (just under 15 ft) long. Its power is provided by two wing-shaped panels almost 6 metres (20 ft) long that are fitted with gallium-arsenide solar cells.

The triangular carrier structure is made from reinforced man-made fibre.

The solar generator charges a 22-cell nickel-hydrogen battery, which becomes the power supply when the satellite is in the shadow of the earth (about half the 100 minute orbiting time).

The average transmitter power is 660 W. The central electronics circuits are based on ASICs (Application Specific ICs). The computing power of the multi-processor network is about 100 mips (million instructions per second). At full load, up to 11,000 telephone conversations can be handled simultaneously.

The RF stages of the transmitter and receiver are based on MMICs (Monolithic Microwave ICs), while the amplifiers in the receiver use low-noise GAS-FETs.

Communication in the Ka-band to other Iridium satellites is carried out by four antennas (two North-South and two East-West) on frequencies between 23.18 GHz and 23.38 GHz.

Direct communication with mobile phones and pagers takes place in the L-band between 1616 and 1626.5 MHz via three main antennas and 16 spotbeams.

Communications with the gateways is via four movable antennas in the Ka-band (downlink 19.4–19.6 Ghz and uplink 29.1–29.3 GHz).

All antennas consist of flat panels and use state-of-the-art technology.

As mentioned earlier, the 80 satellites were designed and manufactured by Lockheed Martin. This company has to date built more LEO satellites than any other organization in the western world. In spite of all this experience, there were a number of failures, and these set back the overall program by about six months.

Most of the satellites are launched in groups of five by a Boeing Delta II Rocket from the Vandenberg launch pad in California.

Some satellites were launched in groups of seven by a Russian Proton Rocket from the Baikonur Kosmodrom site in Kazakhstan.

Some satellites will be launched by China, but the Great Walls Industries Corporation's 'Long March 2C/SD' rockets can accommodate only two satellites at a time.

The spare satellites will be launched by Delta II and Long March 2C/SD rockets. At the end of last year, seven of the 14 spare and control satellites were already in orbit.

Quickroute Systems

Quickroute Systems, which, in the space of only a few years, has established itself as one of the market leaders in the software simulation and schematic PCB design field, have recently introduced The IdeaFactory, which offers even a non-technical person a new way to drag and drop innovative, interactive multimedia models.

With this new product, you can create animated simulations on screen and explore technology, science, electronics, and mathematics, in an innovative, fun and interactive environment.

Quickroute Systems Managing Director, Dr Ian Frost, told our special reporter: "The IdeaFactory can be the visual programming tool you've dreamed of. You can load and visualize data in real time, create and interact with simple (or complex) models. Explore electronics and logic, and combine animation with sound to produce amazingly sophisticated models. Virtual instruments, 2D and 3D charts, on-screen switches, lights and key-pads, combine with maths and electronic objects in an intuitive way. Whether it's creating animated action games, modelling a physics experiment or designing a logic system, the IdeaFactory is there to help."

At the launch of the IdeaFactory, Dr Frost said: "This product offers everyone an interactive and intuitive way to model and interact with information. If you have found spread sheets too limited, 4GL or ',macro languages' too daunting, then the IdeaFactory could provide you with a new virtual laboratory for exploring your ideas."

The IdeaFactory can help with modelling for instance, if you look at probability, simply drag a die (a random number generator) and wire it to a bar chart. Press the GO button and watch the numbers appear on the bar chart. Similarly, you can model and plot the path of a projectile and create a UFO game with animation and sound effects, analyse a logic circuit, or create an animated lift under control of buttons placed on different floors. You can also create worksheets and presentations using the built-in text and animation facilities.

More than just a circuit simulator, The IdeaFactory gives you, according to Quickroute, 'a vast range of modules, many of which have a rich set of options. Modules include logic gates, LEDs, 7-segment displays, switches, sliders, mathematical modules (+, –, ×, :, sin, cos, exp, power, 1/x, summation, and so on), 2D (x/y) and 3D (x/y/z) graphs with triggered, clear 8-trace logic analyser, bar chart, chart recorder with four traces and gain/offset animation, bitmaps, moving bitmaps (so you can create games, etc.), triggered sounds, on-screen keypads, keyboard triggering (e.g., space bar triggers an event), number (start/step/stop) and random number generators, triggers, comparators, sequences, and much more.

The recommended retail price, excluding p&p and VAT, of The IdeaFactory is £49. It works on Windows 3.1, 95 and compatible.

Established in 1995, Quickroute Systems sells a range of technical products that are designed to be easy to use and good value. Products include Quickroute, MExpress, SMARTroute and SymbolWizard.

According to the company, if you are interested in electronic design, Quickroute could be what your are looking for. Quickroute is really different from other packages on the market as it integrates simulation, schematic design and PCB design into one package, so you only have to learn one package wich not only saves you time, but makes the job easier and helps you to control the job more effectively.

Creating diagrams in Quickroute 4 – the latest version – is, claims the company, "easy". Symbols can be selected quickly from the comprehensive libraries with Quickroute's fast new symbol browser. Symbol idents are generated automatically for you and symbol pins can be wired conveniently with the automatic orthogonal or free-form line placement tools.

Ian Frost told EE: "You can annotate the schematic with page frames, text or graphics (circles, rectangles, etc.) and Quickroute also includes facilities to make creating data buses and power rails easier. For larger designs, you can split your schematic into eight separate sheets, each of which can be 60×60 cm in size.

"After creating your schematic, you can use the simulator to check the design. Probes can be placed directly on to the schematic together with any requisite generators (pulse, since, DC, etc.). Then, simply click on the simulate button to run the simulation. Time domain waveforms are displayed directly beneath the schematic. The simulator can also display FFT (Fast Fourier Transform) spectra."

"Once you are happy with your schematic design, you can capture the schematic, that is, turn it automatically into a PCB rats nest. To do this, just click on the schematic capture button. After capture, all the schematic symbols are replaced by a suitable PCB symbol and all the necessary connections are placed."

"The PCB rats nest can be routed manually or automatically on one, two, or up to eight copper layers. Solder mask and silk screen are generated automatically and there is a full range of PCB design tools, including copper flood fill, design rule, and connectivity checking."

"Finally, you can print or plot your design, or create a set of suitable files for PCB manufacture (Gerber and Drill files)."

Quickroute 4 is available in four variants, each of which has exactly the same functionality as the others, but a different design capacity. The design capacity is rated in pins, where a pin corresponds to an electronic circuit component terminal."

The company has also introduced the SymbolWizard, which is a new plug-in module for Quickroute 4 that automates the creation of new symbols.

Ian Frost continued: "You can choose from over 100 predefined templates, customize pad size and dimensions, select from a range of silk-screen styles, and SymbolWizard does the rest: automatically creating a suitable schematic and PCB design ready to be added to Quickroute's or your own custom libraries."

"SymbolWizard can be fully customized, and the symbols are shown 'live' as you alter the properties. Supplied with comprehensive documentation, SymbolWizard saves time and ensures consistent results.

Another product in the company's range is MExpress which is now available in its 2.0 version. This is a BASIC for scientists and engineers – it is said to be the development, visualization, and analysis tool for scientists and engineers who are looking for a way to use BASIC like a scripting language, with a power matrix based on numerical methods, a full range of 2D and 3D graphics and visualization tools, and a comprehensive set of GUI (graphical user interface) controls, such as buttons, sliders, radio buttons, menus, windows, and so on.

MExpress includes what Quickroute claims to be is a remarkably easy-to-use interpreter, and can also create FAST 32 executables which you can distribute free of royalties. Amazingly, according to Quickroute, MExpress 2.0 includes all the tools you need to create executables, just type 'compile' at the prompt, and MExpress does the rest.

MExpress 2.0 also includes the M2X utility, which helps convert level 4 M-files into script files suitable for MExpress.

Whether you are loading and analysing data, creating custom visualization tools for use in the lab, running a large model, or producing a commercial engineering software product, MExpress can provide the tools and flexibility you need, maintains Quickroute.

Quickroute 4.0 starts at an RRP of £79

The IdeaFactory starts at an RRP of £49

MExpress starts at an RRP of £149

All prices stated are exclusive of p&p and VAT.

Further information on the company or its products is available from

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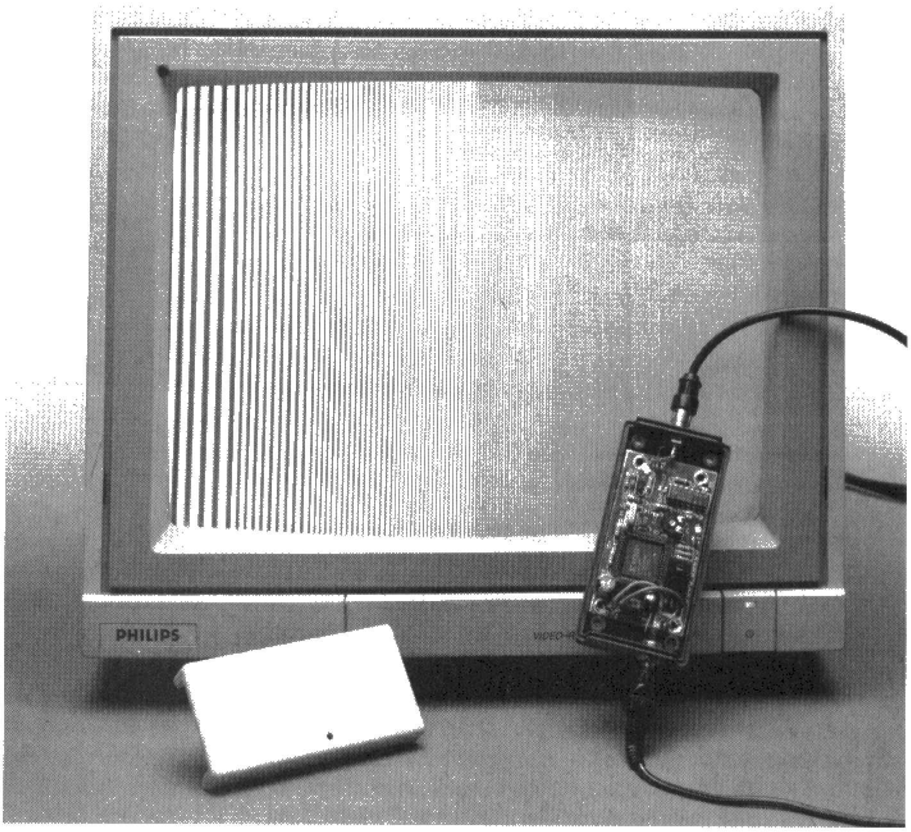
multiburst generator

video test signal from two ICs

In many instances, suspect television receivers and monitors can be tested with a simple test pattern generator as described in this article. The circuit proposed in this, which consists of only a handful of components, generates a series of test bars, the so-called multiburst.



Design by W. den Hollander

INTRODUCTION

Although modern television receivers and monitors are highly immune to noise and interference, there will always be a need for a test pattern generator. The compact circuit presented enables many of the basic functions of a television receiver or monitor to be checked. Owing to its simplicity, it provides only a black-and-white pattern, of course.

DESIGN CONSIDERATIONS

The simple test pattern of grey bars, called a multiburst, generated by the circuit consists of a wave train containing different frequencies at a level of 420 mV_{p-p} (average value 650 mV). The multiburst enables the frequency response, and certain other properties of the system on test to be measured. In a properly adjusted receiver or monitor, all components, with the possible exception of the 5.8 MHz burst, may be present. The reference bar and the 2*T* pulse are repeated in line 330, so the pulse repetition rate (ppr)of these important test signals is 50 Hz.

The multiburst also enables the video amplifiers, sync(hronization) separator and output amplifiers to be tested.

Disregarding the power supply, the

generator is based on two ICs: an in-system programmable logic assembly) and a VCO (voltage-controlled oscillator). The circuit diagram is shown in **Figure 1**.

CIRCUIT DESCRIPTION

The in-system programmable IC (IC_1) contains 36 macrocells and a total of 800 gates. In the present application, it is used to generate the sync(hronization) signal, CS, the blanking signal, CB, and the control voltage for the VCO.

The sync signal, which meets international standards, is available at pin 7 of IC_1, and from there applied to output amplifier T_1 via resistor R_{14}.

The blanking signal, manifested by a logic low level at pin 14 of IC_1, is used to disable the oscillator in IC_2 during the sync pulse.

As shown by the timing diagram in **Figure 2**, a pulse appears at each of outputs D_0–D_7 during the line period (64 μs). These pulses are converted into a staircase consisting of direct voltage steps. The staircase signal is used to control the VCO in IC_2 via pin 9, resulting in a frequency-modulated output signal – the multiburst – at pin 4 of IC_2.

The central frequency of the VCO is determined by the values of R_{12} and C_3 and the setting of P_1. With values as specified and P_1 adjusted for a central frequency of 1 MHz, the output frequency rises in eight steps to a value of 10.5 MHz.

The d.c. operating point of output amplifier T_1 is determined by the values of R_{15} and R_{16}. The video and sync signals are superimposed on this via R_{13}, R_{14} and C_4. The amplifier is designed to have an output impedance of 75 Ω at an output voltage of 1 V_{p-p}.

The important signals in the circuit are summarized in **Figure 3**. In this diagram, the sync signal, on to which the output signal of the VCO is superimposed, is on the top line. The blanking signal is on the second line and the staircase control voltage for the VCO on the third.

The output signal of the generator is on the bottom line. This shows clearly that at the onset of each horizontal line, that is, every 64 μs, the oscillator is disabled.

Note that the irregularities on the screen images are caused by the sampling process of the oscilloscope used.

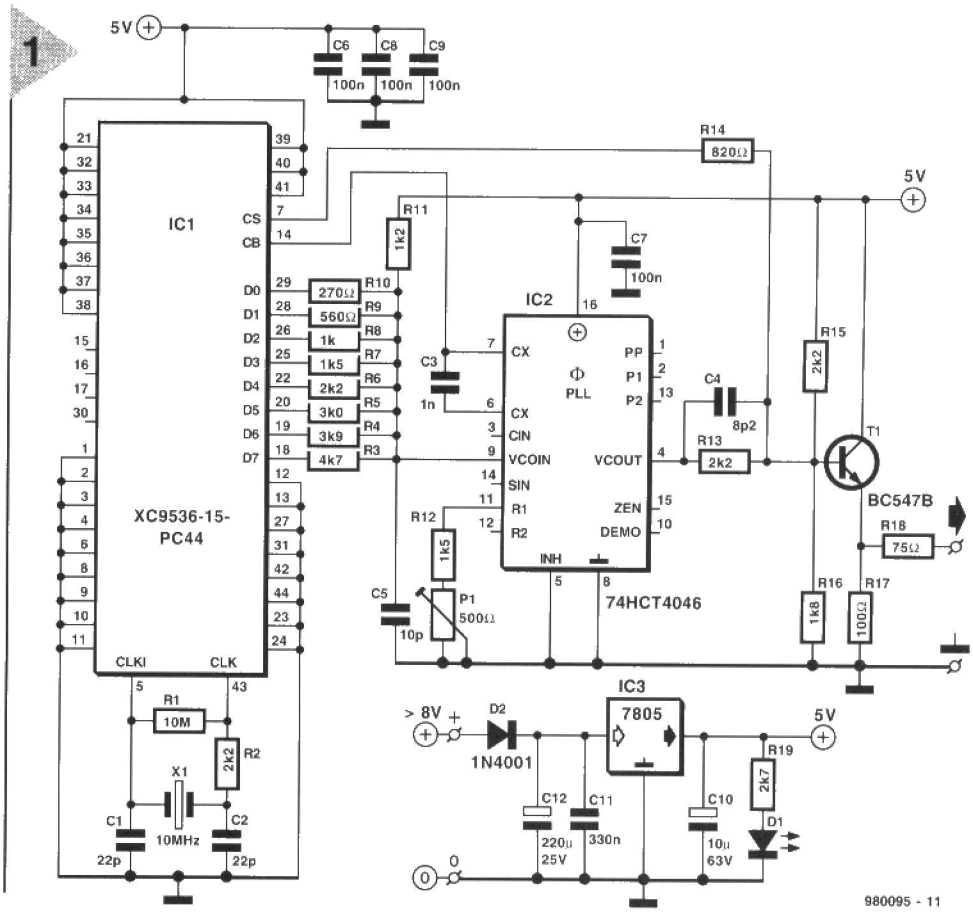


Figure 1. Circuit diagram of the multiburst generator.

The circuit is powered by a simple supply whose output is stabilized at 5 V by regulator IC_3. Diode D_2 prevents damage through inadvertent incorrect polarity of the input voltage. Diode D_1 is a supply-on indicator. The input voltage may be derived from a simple mains adaptor with an output of 9–12 V.

CONSTRUCTION

The generator is conveniently built on the printed-circuit board shown in **Figure 4** (available ready-made – see Readers Services towards the end of this issue).

IC_1 should be placed in a suitable socket: mind the polarity. Do not overlook the wire bridge alongside R_{10}.

TESTING

When the generator has been built and inspected thoroughly, switch on the mains supply to the adaptor. Connect an oscilloscope to the output and adjust P_1 so that the lowest frequency

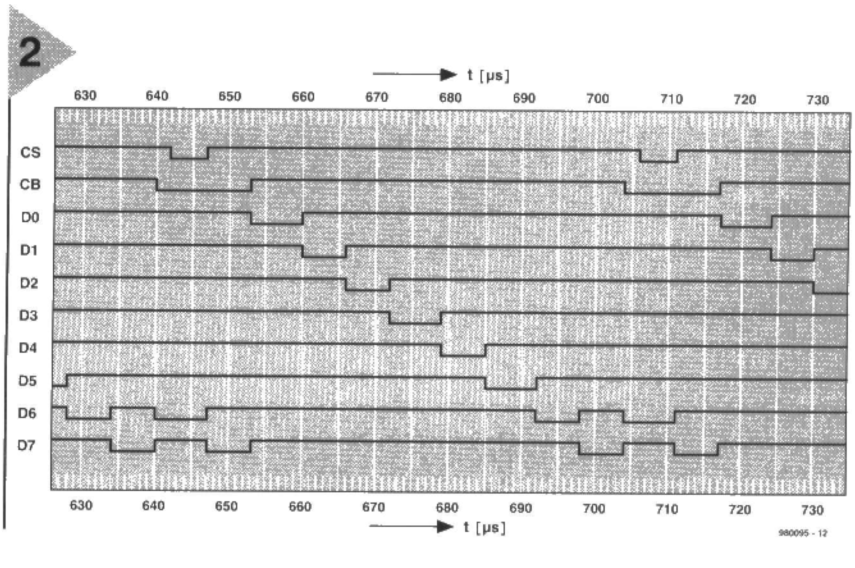


Figure 2. The in-system programmable IC generates a number of digital signals that are the basis of the output test signal.

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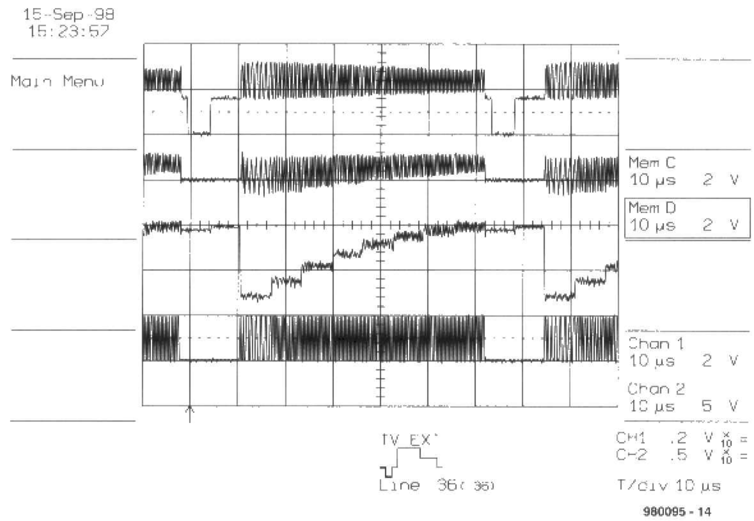


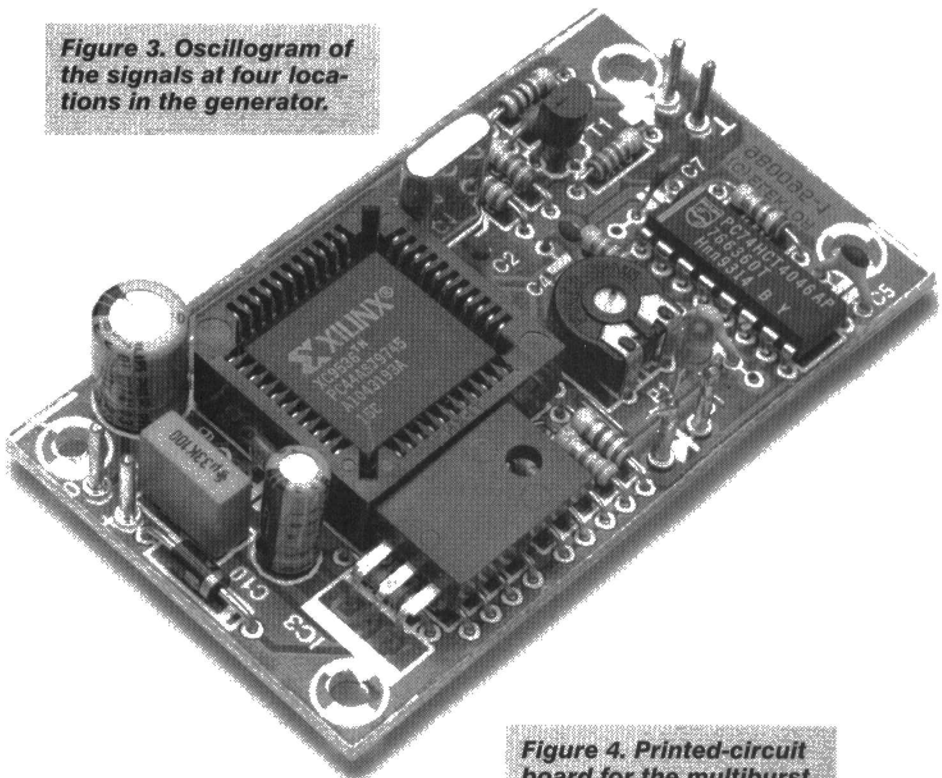
is 1 MHz.

The generator is intended for testing television receivers or monitors that have a field frequency of 50 Hz and 625 lines per picture. If different frequencies are desired, the value of resistors R_3–R_{10} should be altered as required.

Note that, in contrast to proprietary multiburst generators, the present one does not provide a sinusoidal output.

[980095]

Figure 3. Oscillogram of the signals at four locations in the generator.



Parts list

Resistors:
R_1 = 10 MΩ
R_2, R_6, R_{13}, R_{15} = 2.2 kΩ
R_3 = 4.7 kΩ
R_4 = 3.9 kΩ
R_5 = 3.00/3.01 kΩ
R_7, R_{12} = 1.5 kΩ
R_8 = 1 kΩ
R_9 = 560 Ω
R_{10} = 270 Ω
R_{11} = 1.2 kΩ
R_{14} = 820 Ω
R_{16} = 1.8 kΩ
R_{17} = 100 Ω
R_{18} = 75 Ω
R_{19} = 2.7 kΩ
P_1 = 500 Ω preset

Capacitors:
C_1, C_2 = 22 pF
C_3 = 0.001 µF
C_4 = 8.2 pF
C_5 = 10 pF
C_6–C_9 = 0.1 µF, ceramic
C_{10} = 10 µF, 63 V, radial
C_{11} = 0.33 µF
C_{12} = 220 µF, 25 V, radial

Semiconductors:
D_1 = LED, high efficiency, red
D_2 = 1N4001
T_1 = BC547B

Integrated circuits:
IC_1 = XC9536-15-PC44 (Xilinx); available ready programmed under Order no. 986520-1*
IC_2 = 74HCT4046
IC_3 = 7805

Miscellaneous:
X_1 = crystal, 10 MHz
PCB Order no. 980095-C*
Diskette with Jedec source file: Order no. 986029-1*

*(see Readers Services towards the end of this issue)

Figure 4. Printed-circuit board for the multiburst generator.

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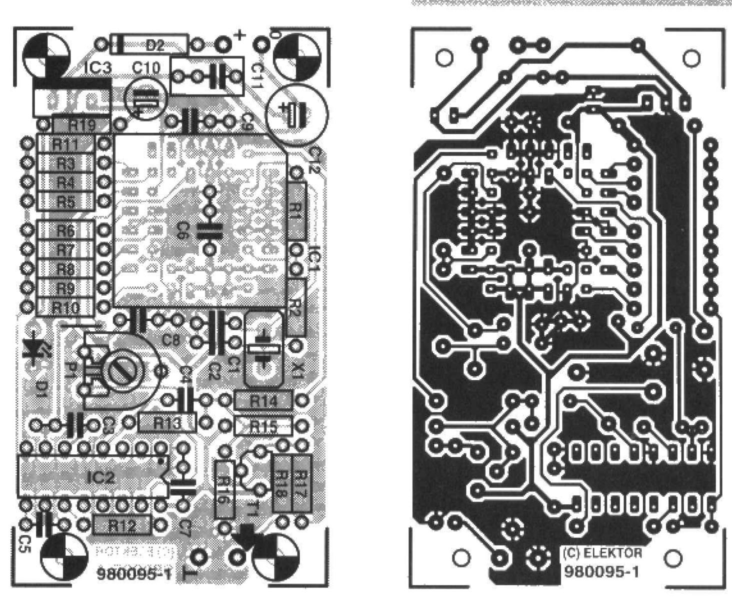
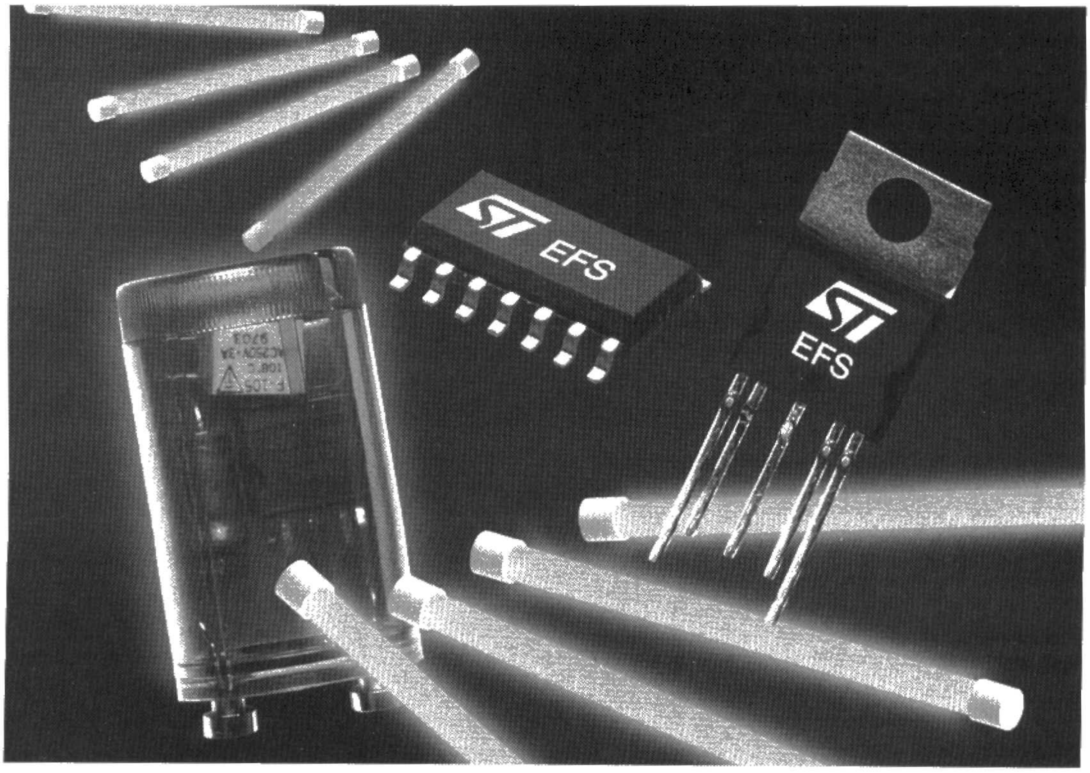


APPLICATION NOTE

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

fluorescent lamp starter

2-chip set from SGS-Thomson



ST Electronics (formerly SGS-Thomson) have earlier this year brought out a 2-chip starter, the EFS (Starlight) Kit, which, in conjunction with four additional passive components, can be used as a direct replacement of the glow switch starter. The kit comprises a driver and an ASD™, which contains a power switch, and a power supply for the driver. The driver is programmed to ensure efficient ignition of the fluorescent tube.

An SGS-Thomson Application
Expanded by G. Kleine

INTRODUCTION

A low pressure fluorescent lamp normally consists of a glass tube, 38 mm in diameter and between 600 mm and 2400 mm long. The tube is filled with a noble gas at a pressure of not more than 4 per cent of atmospheric pressure and also contains a drop of liquid mercury. The interior surface of the tube is coated with phosphor which converts the ultraviolet light produced by the discharge into visible light.

At each end of the tube are electrodes that serve alternately as cathode and anode since these lamps are used in a.c. circuits.

The cathodes of a hot-cathode fluorescent lamp consist of a coiled filament coated with barium-oxide that is held

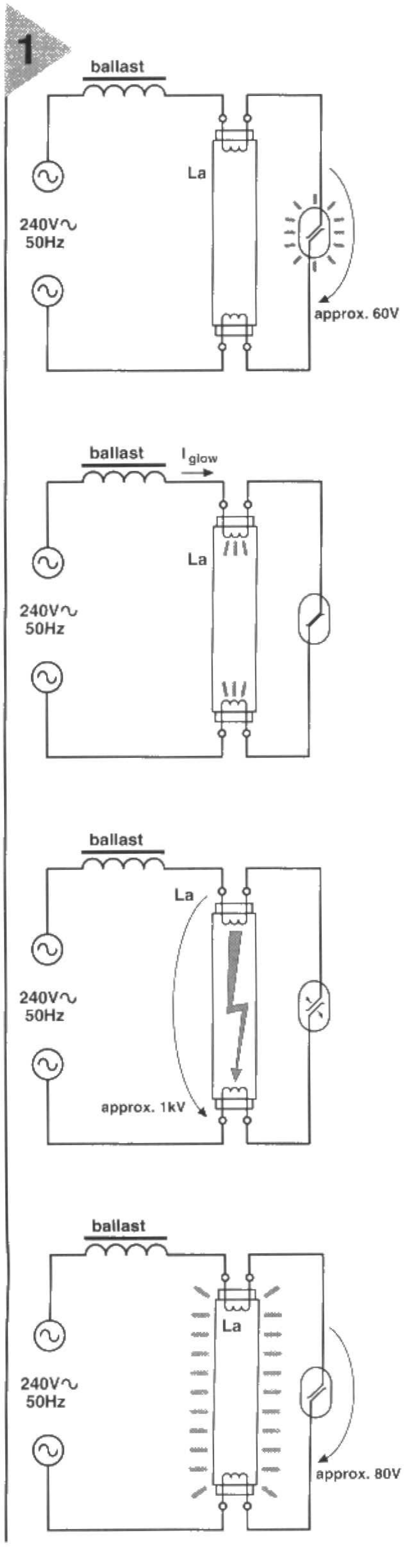


Figure 1. Operation of a fluorescent tube with traditional starter switch.

in place by nickel support wires.

Anodes in the form of metal strips or wires attached to the support wires are used in high-loading tubes, but in low-loading tubes the support wires act as anodes.

The noble gas serves to reduce the rate of evaporation of the barium from the cathode and also to reduce the starting voltage.

The tube cathodes are heated by passing a current through each filament, which causes a large number of electrons to be emitted by the oxide coating. Assuming sufficient voltage is applied across the tube, a glow discharge is set up through the noble gas which excites or ionizes the mercury atoms throughout the tube and establishes a mercury-arc discharge.

A fluorescent tube requires a ballast (usually a choke) to limit the current through the tube, a starter for preheating the cathode filament. In many cases, this is complemented by a power-factor-correcting capacitor.

As the arc current increases, the voltage drop across the choke rises, so that the potential across the tube drops until a balance is reached.

The simplest and most frequently used starting device is the starter switch. When this is closed, a current flows through the ballast and the two cathodes in series, whereupon, as soon as the cathodes reach the emission temperature, local ionization is set up and the ends of the tube begin to glow. The starter switch is then opened rapidly, and the resulting change in current causes a large counter-e.m.f. across the coil, which is applied across the tube and is sufficient to cause the arc to strike.

The operations just described are illustrated in **Figure 1**.

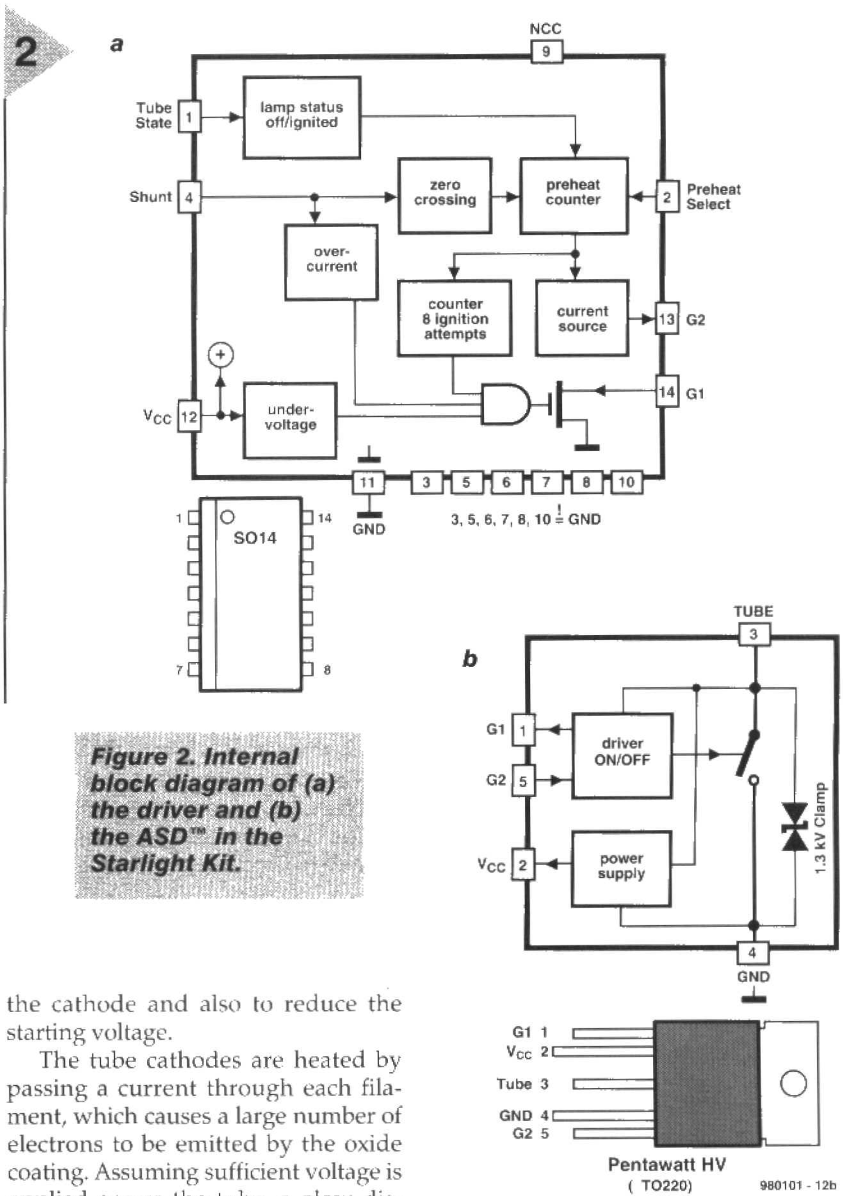


Figure 2. Internal block diagram of (a) the driver and (b) the ASD™ in the Starlight Kit.

Automatic starter switches permit a heating current to flow for a predetermined time before they open and produce the striking pulse. The traditional starting switch is a glow type, in which the switch contacts are mounted on bimetallic strips that bend towards each other when they are heated.

In many cases, bimetal starters have been, or are being, replaced by electronic starters. Current electronic starters for fluorescent lamps use a unidirectional switch, like a MOS transistor or GTO (Gate Turn Off) thyristor. Since a starter is a bidirectional switch it is necessary to use a rectifier bridge and, in addition, 2 or 3 diodes in series with the GTO to get the necessary switch-off effect. The whole switch is controlled with an analogue timer built around a small SCR (Silicon Controlled Rectifier). The switch in the new kit from ST Electronics is a bidirectional type, which substantially reduces the number of

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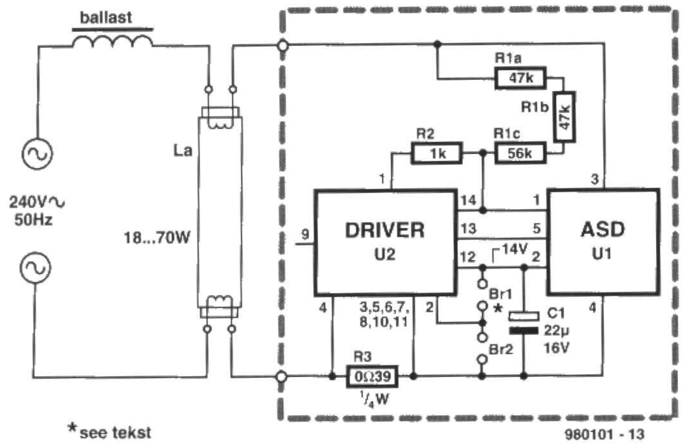

Figure 3. Basic application diagram of the EFS (Starlight) starter.

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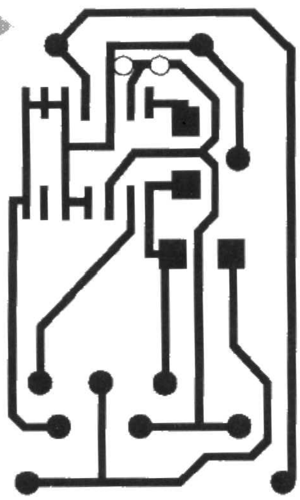

Figure 4. Track layout of the PCB for the Starlight Kit. (200%)

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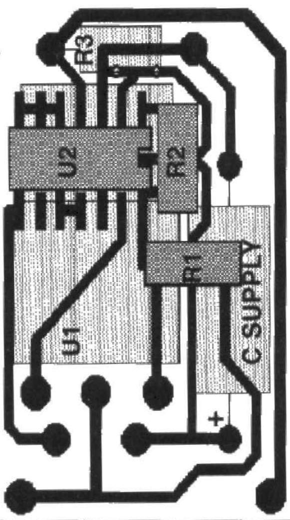

Figure 5. Component layout of the PCB for the Starlight Kit. (200%)

additional components and the power losses (only one forward voltage instead of 5 or 8 depending on the unidirectional version).

BASIC APPLICATION

A block diagram of the driver is shown in **Figure 2a**.

The bidirectional power switch performs two functions:

- preheating the tube;
- igniting the tube.

During the preheating period, the ASD™ conducts hard. The tube is short-circuited by the starter, and the current flows through its filaments. In this condition, the tube cannot light, but the temperature of the filaments rises steadily.

At the end of the preheating period, the filaments of the tube are hot enough to emit electrons into the gas and to permit the gas igniting. The ASD then switches off the preheating current. At that moment, the ballast is equivalent to a current generator where $I = I_{SO}$ (I_{SO} = switch-off current). While the ASD switches off, the starter voltage increases. The amplitude of this high-voltage spike is clamped by the ASD ($U_{BR} \approx 1350$ V). Since the power switch and the tube are in parallel, the striking pulse is applied directly to the tube. The electromagnetic energy of the ballast is then discharged through the tube and the ASD™.

The ASD contains an auxiliary power supply for the driver, a power clamping device (1350 V) and a bidirectional switch (**Figure 2b**).

A fluorescent tube requires a minimum level of energy to be ignited, but this energy depends largely on the temperature of the tube. The lower this temperature, the less energy, and the more difficult it is for the tube to ignite. The energy, E, stored in the ballast, L, is directly proportional to the I_{SO}:

$$E = LI_{SO}^2/2.$$

This means that the required energy, and thus the I_{SO}, is a maximum at the minimum temperature. Results based on experiments show that it is necessary to switch off a current of 350 mA to strike a 58 W tube at –20 °C (with the voltage clamped at 1300 V).

So, the best way for a tube to strike independently of temperature is to keep the I_{SO} at a maximum over the whole temperature range. In practice, the I_{SO} is maintained at 350 mA at temperatures below –10 °C and then allowed to drop gradually to about 180 mA at +75 °C.

AUXILIARY POWER SUPPLY

To reduce the number of components, an auxiliary power supply is incorporated in the ASD, which works directly from the mains. A capacitor at the output of the supply is charged at the beginning and end of each positive half-cycle of the mains voltage. During the preheat period, a part of the current flowing through the ASD is used to charge the output capacitor, so there is no line current distortion. When the tube is ignited, the capacitor is periodically recharged by the ASD to allow monitoring of the tube by the starter kit.

FUNCTIONAL DESCRIPTION

A functional diagram is shown in **Figure 3**. At switch-on, an integrated Under Voltage Lock Out (UVLO) function resets the driver as long as the supply voltage stays below a safe level.

The ignition sequence begins with the preheat period. Two different period lengths are available:

- if pin 2 is connected to ground, the preheat period is 1.5 s;
- if pin 2 is connected to V_{CC}, the preheat period is 2.5 s.

Recommended components:

R_1 = 150 kΩ, 1/2 W, SMD
R_2 = 1 kΩ or 2 kΩ (see text) 0.5 W SMD
R_3 = 0.39 Ω, 1/4 W
All resistors 5%

Capacitors:
C = 22 µF, 16 V, 10%

Integrated circuits:
See Table

During the preheat period, the driver maintains the ASD in the full on state, making the starter equivalent to a closed switch.

At the end of the preheat period, the starter ignites the fluorescent tube. To this end, the driver continuously monitors the current through the starter. When the current reaches the switch-off level (350 mA), the driver turns off the ASD. This causes a high-voltage pulse to be induced across the tube, which is limited by the ASD breakdown voltage of 1350 V.

The driver senses the state of the tube (on or off). When the tube fails to strike and remains off for eight periods of the mains voltage, a new preheat period, shorter than the first, is begun, followed by a new ignition attempt. The driver will try to fire the tube eight times. If none of these attempts is successful, the driver is set to the standby mode, and the whole starter stops until the mains is switched off and then on again.

Once the tube is ignited, the driver stays in the standby mode, but continues to monitor the state of the tube. The ASD applies a short high-voltage pulse of 1 mJ at the beginning of each positive mains half-cycle. If the mains voltage drops briefly, the tube turns off momentarily, but the short pulse is sufficient to sustain the arc in the tube, so avoiding the need for a new ignition sequence.

During normal operation of the tube, the short pulse is masked by the tube conduction. If the mains is interrupted for some time, the lamp is switched off completely and a new ignition sequence is started as soon as the mains voltage is restored.

CONSTRUCTION

The complete starter may be built on the printed-circuit board shown in **Figures 4** and **5**. This fits nicely in the case of a defect glow type starter.

The components are SMD (surface-mount device) types. Start the soldering with the resistors, then the capacitor, and finally the two ICs.

The preheat time must then be set: pin 2 is the preheat time select pin. To select a 1.5 s preheat time, drill and cut the V_{CC} to pin 2 at the metallized hole. To select a 2.5 s preheat time, drill and cut the GND to pin 2. Either of these actions must be carried out to avoid a supply short circuit.

FINALLY ...

When the board has been fitted in a glow type starter case, insert it into the relevant connector on the tube holder. When the lamp is switched on, it should ignite at once. If it does not, lenghten the preheat time.

If increasing the preheat time does not help or if instead of the eight attempts at igniting the tube there is only one, the tube may have an integral series compensation capacitor as shown in **Figure 6**. In such a case, there is only one attempt at igniting the tube, but this should be sufficient.

There is an arrangement for two special tubes in series, the so-called twin tube configuration, as shown in **Figure 7**. This uses two starters, but only one ballast. The ST Electronics starter can be used in this arrangement if the value of R_2 is increased to 2 kΩ. If in this configuration the tubes do not ignite, turn one of the starters 180° in its socket.

[980101]

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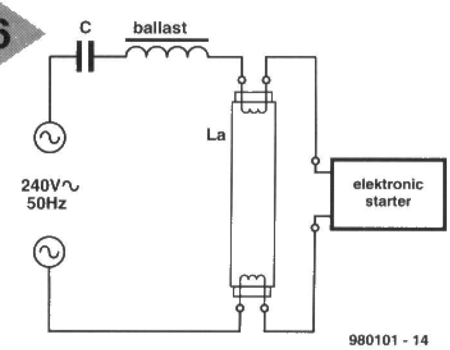

Figure 6. Some fluorescent tubes have an integral series compensation capacitor.

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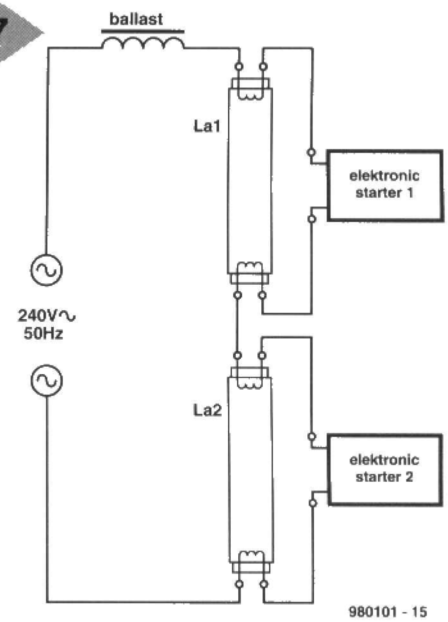

Figure 7. Twin tube configuration.

EFS Starlight Kit	*EFS1*	*EFS2*	*EFS3*
Tube rating (W)	*36–58*	*18–70*	*18–125*
Umgebungstemperatur [°C]	*5 to 75*	*–20 to 75*	*–40 to 85*
Twin tube serial connection	*Yes*	*Yes*	*Yes*
Driver (U_2)	*EFS1-A*	*EFS2-A*	*EFS3-A*
ASD™ (U_1)	*EFS1-1*	*EFS2-1*	*EFS3-1*

FROM RUSSIA WITH VISION:

The men who made television

By Greg Grant

Television (TV), that theatre-in-the-round of the world community, is about to be digitised. Amid the moderate welter of exhibitions, lectures and other activities that are likely to accompany the launch of this latest addition to the informational-entertainment spectrum little, I suspect, will be heard of the Russian émigrés who made it all possible, on both sides of the Atlantic.

They deserve better than a passing mention in the credits of some TV awards binge, those all-too-frequently held ego trips for the technologically challenged.

THE BEGINNINGS

There had long been ideas for transmitting pictures over great distances of course, most notably Alexander Bain's British patent of 1841. Twenty years later, still pictures were being transmitted by telegraphy and the discovery, in 1873, of the photoconductive properties of selenium, brought several more ideas on picture transmission to public attention. What Boris Rosing proposed however was far in advance of anything that had been imagined hitherto.

The Professor of Physics at St. Petersburg Technological Institute, Rosing was the earliest advocate of transmitting moving pictures to a distant location. He was also the first scientist to envisage using Karl Ferdinand Braun's oscilloscope for their reception.

In fact, he actually built the experimental system shown in **Figure 1**, '...which used mirror polyhedron drum scanning at the transmitter,' (1) a system of scanning that had been developed by Lazare Weiler as early as 1889. The mirrors had magnets attached to them which '...acted on groups of fixed coils, set close to the polyhedrons, setting up alternating currents in them.' (2)

Two alternating currents were created, one by the revolving polyhedrons, the other by the second polyhedron. Each current then travelled along separate cable pairs to the receiver, where they activated two electromagnets, which provided beam deflection.

Quite apart from being, so far as we know, the first experimental TV system built anywhere, Rosing's initiative greatly influenced later developments.

In the following year, 1908, the Scottish engineer Alan Campbell Swinton wrote a letter to the scientific journal Nature in which he outlined the basic structure of an all-electronic TV system. The whole concept was an astonishing piece of imaginative thinking, and some 30 years ahead of the technology of the day.

THE BREAKTHROUGH

One of the men influenced by the Russian experiment was Vladimir Zworykin, who had in fact '...worked with Rosing... and had been impressed by his approach.' (3). Having served as a communications officer in the Russian army in World War One, Zworykin moved to Western Europe where he studied at the College de France, prior to emigrating to the United States in 1919.

On arrival, he joined the Westinghouse Electrical Corporation and began to develop evacuated tubes for TV. By 1925, he had produced a device he termed an Iconoscope, from the Greek words Eikon meaning 'Image' and Skopein, meaning 'To Watch.'

For the next seven years or so, Zworykin developed his brainchild which '... though difficult to manufacture and operate...[was]...a great advance on the earlier mechanical methods.' (4). The Iconoscope, shown in **Figure 2**, looked like nothing so much as one of the more arcane laboratory retorts.

The scene to be transmitted was focused via a lens on to a screen, which was an integral part of the tube. This was the real breakthrough, for the screen supported a mosaic of very small blobs of silver, coated with a very light-sensitive preparation, derived from caesium oxide.

When the scene was projected on to this surface the screen released electrons, resulting in a positive charge on the silver blobs, one that was proportional to the intensity of the light reflected from the scene.

The screen was attached to a sheet of mica, some 12 centimetres (cm) wide, by 9 cm high, whose metal side served as a Signal Plate. This last '...was scanned by a high-speed electron beam, which penetrated through the oxide layer forming a temporary conducting path, permitting the locally-stored charge to flow off through the Signal Plate' (5), which fed the first stage of the camera pre-amplifier.

The tube's electron gun assembly was located at an angle to the screen, the electron beam being used to scan the screen via pairs of deflection coils. The scene therefore was scanned from left to right, with a series of some 490 horizontal lines. In the camera pre-amplifier, a

technology and the new millennium

The advent of a new era is usually a time for reflection and stock-taking. The millennium currently approaching Platform Earth is no different. Reflecting on the progress of electronic technology over the second half of the millennium now passing away is sobering, to say the least.

To the Victorians and their successor, the Telegraph was the epitome of technical progress, along with the Trans-Atlantic cable system that was its highway. To pre-World War II Britons, the Television was no less marvellous. Yet, one has passed away, and the other is being changed significantly.

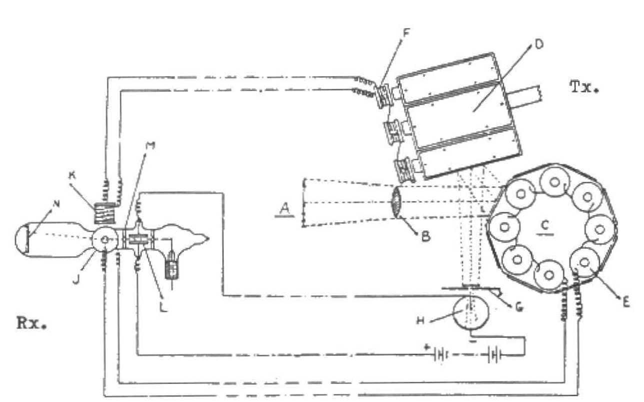

Figure 1. Boris Rosing's TV system. A: Scene. B: Lens. CD: Mirror Polyhedrons. EF: AC generating coils. G: Diaphragm with Aperture admitting light to H. H: Photo-cell. J: Horizontal deflection coil. K: Vertical deflection coil. L: Plates, controlled by H. N: Fluorescent screen.

voltage varying with the intensity of the light along each scan line appeared, allowing an electrical image to be developed from the optical one.

This device became the ancestor of all other camera tubes, in that they majoratively work with electron beam scanning of a picture, giving transverse conductivity, capable of storing a charge released in response to light. Nevertheless, being a high velocity tube, cameras based on it suffered from the absence of a black signal output, limited sensitivity and spurious signals, this last the result of secondary emission.

Consequently, the picture was far from clear, the images appearing more like shadows. That far more work was required on the device was reflected in Zworykin's first patent application being turned down in 1925.

Five years later, the Radio Corporation of America, (RCA), took over Westinghouse's electronic research and the man in charge at RCA was yet another Russian émigré, David Sarnoff. Born in Minsk, Belarus, in 1891, his pre-ordained career (that of Talmudic scholarship) was abandoned when his family emigrated to the United States in 1900.

In 1906, Sarnoff became a Messenger Boy in a Telegraph office and, with the money he had earned there, taught himself the Morse Code and Operating procedures. He then joined the American Marconi Company as a Radio Operator. After a spell of sea duty, Sarnoff was appointed to the Company's station on top of the Wannamaker Department Store in Manhattan where, on the 14th of April 1912, he picked up the distress signal from the British liner Titanic.

Where the vessel's sinking was a tragedy for so many, it was the making of young Sarnoff. He stayed at his post for the next 72 hours, non-stop. The Company awarded him with accelerated promotion and by 1916 he was an Assistant Traffic Manager.

On the 17th October 1919, the American General Electric Company and the

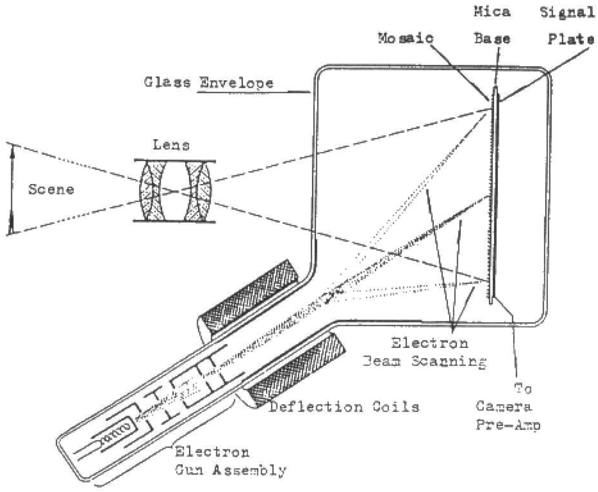

Figure 2. Vladimir Zworykin's Iconoscope of 1933.

American Marconi Company merged to form the RCA. Two years later Sarnoff became the new corporation's Commercial Manager and began to exercise another of his gifts: the ability to identify technical developments that would succeed in the marketplace.

Thanks to the nature of its creation, RCA held some 2,000 patents and Sarnoff wrote to the Board of Directors that '...the technical name for seeing as well as hearing by radio will come to pass in due course.' (6)

Consequently, when he discovered Zworykin was now one of RCA's assets, he gave him '...four or five men to assist him and steps were taken to improve his patent position.' (7) Three years later Zworykin published the earliest description of a TV transmitting tube using cathode ray scanning and charge storage.

By June 1936 RCA, under Sarnoff's direction, had begun a TV service from the top of the Empire State building. The station used 343 lines, interlaced, at 30 frames per second. The power was some eight kilowatts. Three years later the corporation had demonstrated TV at the New York World's Fair and begun a regular, 15-hour per week, broadcast schedule.

They were, nevertheless, still unhappy with the tube, and concluded that '...a magnetic field perpendicular to the mosaic and extending to the source of the electron beam' (8) could improve matters. Two months after beginning their weekly broadcasts, RCA announced the arrival of the Orthiconoscope, or Orthicon for short, the prefix coming from the Greek word for 'Straight.'

This tube, shown in **Figure 3**, was the brainchild of RCA's research engineers Harley Iams and Albert Rose

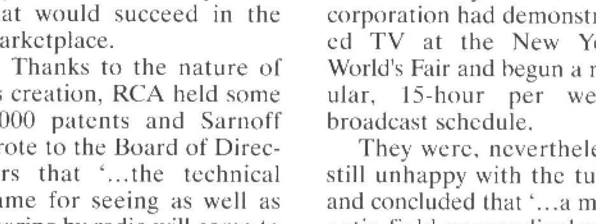

Figure 3. RCA's Orthicon of 1939.

and was a considerable improvement on the Iconoscope, its operating efficiency being such that '... with a target photosensitivity of one microamp (μA) per lumen [it] exhibited approximately the same operating sensitivity as Iconoscopes with a target photosensitivity of 10 μA per lumen.' (9)

Transmission of a 441-line picture was possible and the tube's maximum signal current was some 300 times greater than the noise in a conventional amplifier.

BRITISH DEVELOPMENTS

1933 was an important year for TV development in Britain also. Two research engineers, W.F. Tedham and J.D. McGee, produced the first signals from what came to be termed an Emitron, the outcome of a research programme directed by yet another Russian émigré, Isaac Shoenberg.

Born in Pinsk in 1880, and educated at Kiev Polytechnic Institute, Shoenberg joined the Aisenstein Company in 1905 and remained with them when, two years later, it became the Russian Marconi Company.

Shoenberg had already helped to install the first radio station in Russia, prior to coming to London to continue his studies at the Royal College of Science. Nine years later he was General Manager of the Columbia Gramophone Company and when, in 1931, it merged with the rival Gramophone Company (HMV) to form Electrical and Musical Industries (EMI), he became the new conglomerate's Director of Research and Head of Patents.

HMV had already begun to look into TV in 1930, the year the company started work on cathode ray tubes which, at this time, '... needed to advance a long way from their current status as somewhat exotic tools for measuring and observing waveforms.' (10) Before matters could move forward however, TV standards and parameters had to be considered and defined. Immediately after the merger therefore EMI set about determining these, the company

constructing an experimental system giving a 150-line picture solely for this purpose.

Shoenberg was swiftly appointed to lead the research team developing a viable, high-definition TV system and, as Chief Engineer of this multi-disciplined group he chose Alan Blumlein, one of the most gifted electronics engineers in Britain at that time. Just how able Blumlein was can be gauged from the fact that, at the time of his tragic early death, he held no fewer than 128 patents, roughly one for every six weeks of his working life!

The Emitron, shown in **Figure 4**, operated in a similar manner to the Iconoscope and so suffered from similar problems such as low sensitivity, spurious signals and poor picture definition, this last the result of its oblique scanning. Consequently, the tube's efficiency was only some 5% of its possible maximum.

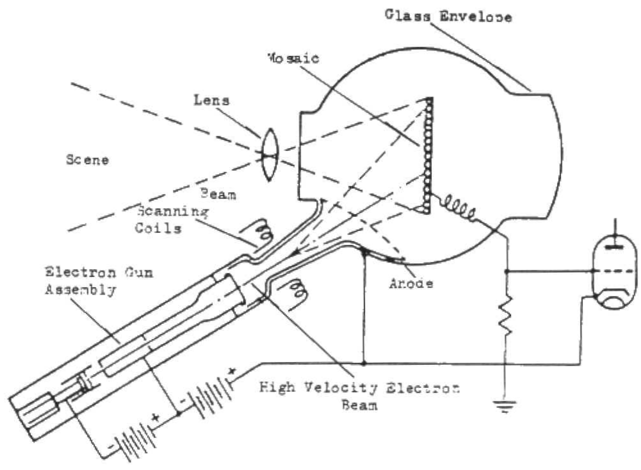

Figure 4. EMI's Emitron of 1933.

Over the next two years however a small number of technical developments - all of which, with the exception of RCA's Interlaced Scanning, made by Shoenberg's team - would improve the Emitron's efficiency considerably.

In 1934 two other members of the team, Sidney Rodda and Hans Lubszynski, developed an image section for the Emitron and suggested that, by separating the photo-emission function from that of the charge storage, the tube's efficiency could be further improved. The result of this was the Super Emitron, shown in **Figure 5**.

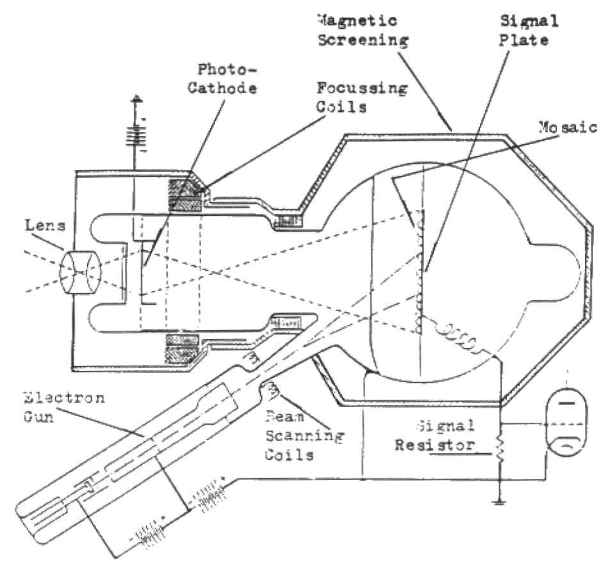

Figure 5. EMI's Super Emitron of 1934.

In this tube, the scene to be transmitted is focused on to a small, transparent photo conducting cathode, from where it releases photo-electrons. There are accelerated by an electric field and focused by the short magnetic field produced by the focusing coils, forming an electron image on the mosaic. As a result of the separation ' '...of photo-cathode and insulating mosaic...a gain in efficiency of conversion of the light into electrons by a factor of three or four [was] achieved.' (11)

The Super Emitron gave a good picture with about 20% of the scene lighting required by its predecessor. First used in 1937, this camera tube proved particularly adept in the outside broadcast field. In the same year Alan Blumlein and J.D. McGee patented a Cathode Potential Stabilization (CPS) technique which led to the CPS Emitron, shown in **Figure 6**.

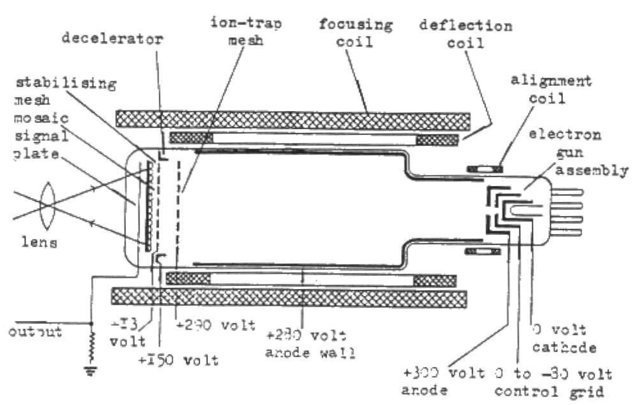

Figure 6. EMI's Cathode Potential Stabilization Emitron of 1937.

Here at last was the viable, portable pick-up tube most design groups had been aiming at. It was 35.5 centimetres (cms) in length and 8.9 cms in diameter. The electron gun was a relatively simple affair, tightly arranged at the neck of the tube.

At the other end the target assembly and signal plate were located, both attached to the tube wall. A stabilizing mesh was placed about 1 millimetre (mm) from the target assembly, surrounded by a decelerator, in front of which was an ion-trap. Running the length of the tube, from the ion-trap to the front of the anode, was the internal wall anode.

Line and field deflection was provided by four coils mounted on the outside of the tube, whilst smaller alignment coils were wrapped around the narrow neck, close to the electron-gun assembly. Finally, there was the focusing coil, which surrounded the tube and produced a magnetic field aligned with the tube's axis. The voltages shown are typical values.

In comparison with contemporary tubes, the CPS Emitron was considerably superior, having greater definition and sensitivity than either the Orthicon or the Super Emitron. Its picture geometry and stability were better than those of the Orthicon and its signal-to-noise ratio at lower levels of scene illumination was greater than that of the Super Emitron. It was also robust, an important factor in outside broadcast work.

OTHER INNOVATIONS

Camera tubes were by no means the only developments undertaken by Shoenberg's team. Blumlein and another team member, E.L.C. White, developed improved cables, some imaginative camera arrangements and new circuit designs. Among the latter was the Long Tailed Pair, a circuit created

originally to reduce the considerable interference the team experienced with video cables.

Shoenberg was also the driving force behind the creation of the Marconi-EMI Television Company in May, 1934. This was a sensible arrangement since '...EMI possessed a knowledge of camera tube manufacture which Marconi's did not, but conversely the Marconi Company, by reason of long experience of facsimile transmission and wideband modulation...were in possession of vital knowledge which EMI at that time did not have.' (12) The Marconi team therefore concentrated on the transmitters and antennas, EMI on the cameras and receivers.

PUBLIC SERVICE BROADCASTING

From the 2nd of November 1936, the British Broadcasting Corporation (BBC) began a regular, if limited, public television transmission from their studios at Alexandra Palace. The Corporation in fact operated two systems, one developed by the independent inventor John Logie Baird and the other by EMI, so that a choice could be made between them.

The EMI system, whose sound and vision antenna was one of the last designs of the great Marconi engineer C.S. Franklin, won. As a result, from February 1937 onwards, the BBC's programme schedule was broadcast only on EMI's 405-line system. The long tussle between the advocates of the mechanical approach and those of the electronic persuasion was over.

The standards Shoenberg set – 405 linescan and 25 flicker-less pictures per second – would be retained by the BBC until 1964 and the Emitron itself would remain in service until the middle 1950s. Indeed, apart from some moderate improvements such as better resolution, higher quality sound and, of course, colour we are still watching TV which is essentially that of Zworykin, Sarnoff and Shoenberg. A very considerable achievement in so rapidly developing a field as domestic electronics and one that will, shortly, join the long list of technologies that have had their day!

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WHEN ELECTRONICS WAS YOUNG (1)

At the threshold of a new millennium: a look back over centuries past

Standing at the threshold of a new millennium, it is a sobering thought to reflect that static electricity has been known for almost 2500 years: the Greeks discovered that friction on amber (Greek: ελεχτρον – electron) by fur gave rise to attractive forces. However, the word electron was not used until 1897 when J J Thomson discovered the electron as we know it.

Electrical technology and its offspring electronics have had, and still have, a tremendous impact on human society. Today, it would be difficult to imagine a world without electric lights, radio, television, telephone, cars (no ignition), lifts, aircraft. Of course, without electricity there would still have been trains, (mechanical) computers, and other appliances. The development of electrical technology and, later, electronics may be compared with that of hieroglyphs, cuneiform, and printing.

Static electricity was not studied for many centuries after its discovery until the early 1700s, when Gray distinguished between conductors and insulators and Fry found that electricity can be positive and negative.

It is difficult to say when the history of electronics started. Although the work of Gray and Fry was important, as was the invention of the first capacitor, or Leyden jar, in 1745, by von Kleist (and, almost a year later, by Muschenbroek at the University of Leyden in the Netherlands), but these were still concerned with static electricity. Electronics as we know it is the science and technology of the conduction of electricity, that is, the movement of electrons, in a gas, vacuum, or semiconductor. The conduction of electricity in other materials or substances is really the domain of electrical technology.

The study of electricity started so ably by 18th century pioneers like Gray, Fry, Muschenbroek, and von Kleist, led in 1800 to the invention of the dry battery by Alessandro Volta, followed in 1803 by Ritter's invention of the rechargeable battery. Since the supply of electric power provided by such batteries is important to electronics, the year 1800 seems a good starting point for a short overview of the history of electronics although, strictly speaking, almost all of that history really belongs to 'our' century: the 20th.

Over the coming months, we shall have a look at a number of milestones in the history of electronics and the men and women who made it all possible.

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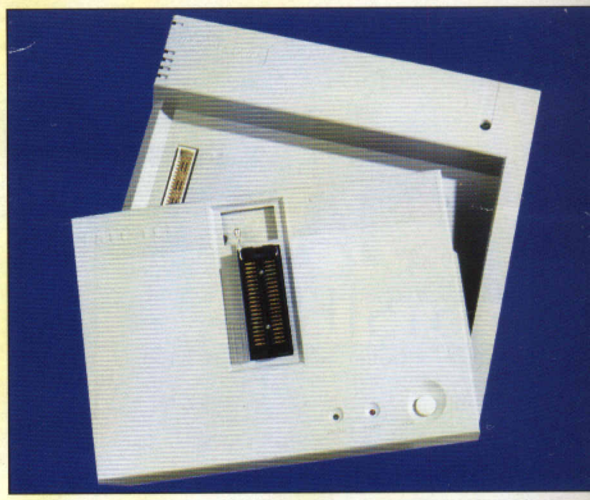

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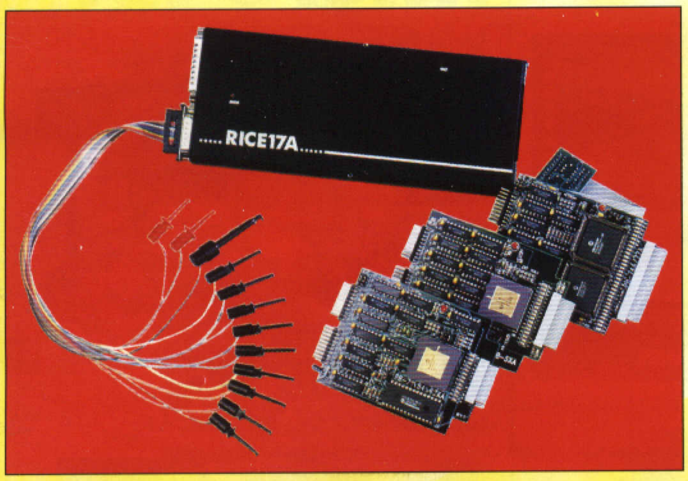

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